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Gladstone
Healthy Harbour
Partnership



2026 TECHNICAL REPORT

2026 GLADSTONE HARBOUR REPORT CARD

Authorship statement

This Gladstone Healthy Harbour Partnership (GHHP) Technical Report was written based on material from several separate project reports. Authorship of the GHHP Technical Report is shared by the authors of each of those project reports and the GHHP Research Officer. They summarised the project reports and supplied additional material. The authors of the project reports contributed to the final product. They are listed here by the section/s of the report to which they contributed.

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- GHHP Management Committee (listed below)

GHHP Partners



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CQG Consulting
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Disclaimer

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Executive Summary

Context

The 2026 Gladstone Harbour Report Card evaluates four key aspects of harbour health: Environmental, Social, Cultural and Economic. The report assesses the health of the environment across 13 zones within and around Gladstone Harbour using monitoring data collected between 1 July 2025 and 30 June 2026. It includes updated Environmental and Economic results, while Social and Cultural results carry forward from previous assessments. The Economic component is partially updated, with Economic Value results retained from the 2022 report. Indicator scores ranging from 0.00 to 1.00 translate into grades from Very Good (A) to Very Poor (E) (Figure 1).



Figure 1 | Grading scheme used to convert scores to grades in the 2026 Gladstone Harbour Report Card for each component of harbour health.

Overall component grades

All four components achieved a Good (B) grade in the 2026 Gladstone Harbour Report Card (Figure 2). Environmental, Social and Cultural components each recorded a score of 0.68, while the Economic component achieved a score of 0.73. Social and Cultural scores are based on previous assessments and have been carried forward.

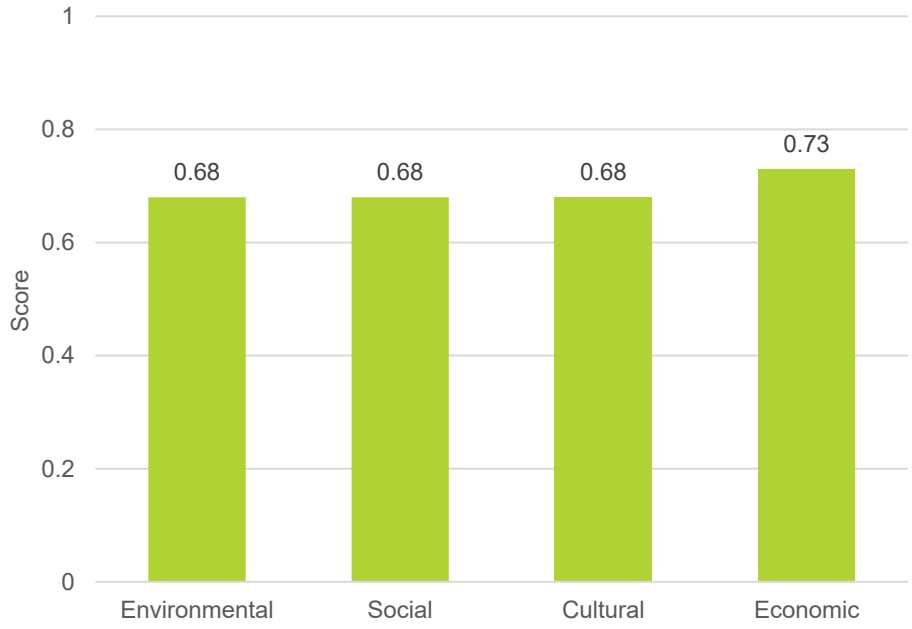

Figure 2 | Overall scores for each of the four components of the Gladstone Harbour Report Card.

Environmental

The Environmental component maintained a Good (B) grade in 2026, despite a small decrease in score from 0.70 in 2025 to 0.68 in 2026.

- Water and Sediment Quality maintained a Very Good (A) grade with a score of 0.87. Both sub-indicators remained consistent between years, with Water quality recording a score of 0.78 in 2026 (0.79 in 2025) and Sediment quality remaining stable at 0.96 (Table 1).
- Habitat conditions remained stable in 2026, retaining a Satisfactory (C) grade and improving marginally from 0.51 in 2025 to 0.52. This increase reflected slightly higher Coral scores, although Coral continued to receive a Very Poor (E) grade. Seagrass remained in good condition, achieving a Good (B) grade with a score of 0.78. Although slightly lower than 2025 (0.81), these results exceeded those recorded in 2024 (0.68). Mangroves were not assessed in 2026.
- Fish and Crabs retained a Good (B) grade despite a decline in score from 0.71 in 2025 to 0.65 in 2026. Fish health continued to record high scores, decreasing only marginally from 0.91 in 2025 to 0.87 in 2026 and maintaining a Very Good (A) grade. In contrast, Fish recruitment was more variable, declining from a Good (B) grade and score of 0.70 in 2025 to a Satisfactory (C) grade and score of 0.58 in 2026. Mud crab remained stable, with scores of 0.51 in 2026 and 0.54 in 2025, maintaining a Satisfactory (C) grade.

Table 1 | Environmental indicator group scores used in the 2026 Gladstone Harbour Report Card.

Zone	Water and Sediment Quality	Habitats	Fish and Crabs
1. The Narrows	0.82	0.77	0.66
2. Graham Creek	0.88	0.73	0.61
3. Western Basin	0.85	0.74	0.87
4. Boat Creek	0.79	0.65	0.75
5. Inner Harbour	0.90	0.59	0.53
6. Calliope Estuary	0.89	0.73	0.68
7. Auckland Inlet	0.81	0.47	0.59
8. Mid Harbour	0.90	0.45	0.73
9. South Trees Inlet	0.87	0.71	0.66
10. Boyne Estuary	0.82	0.66	0.84
11. Outer Harbour	0.95	0.36	0.87
12. Colosseum Inlet	0.94	0.64	0.66
13. Rodds Bay	0.93	0.82	0.70
Harbour score	0.87	0.52	0.65

Water and Sediment Quality

Water quality

Water quality across Gladstone Harbour retained a Good (B) grade in 2026, with the overall harbour score increasing to 0.78 from 0.75 in 2025 (Table 2). The high scores were driven by consistently high dissolved metal scores across all monitoring zones and strong physicochemical results. Improvements in physicochemical scores were recorded in several zones, including Graham Creek, Outer Harbour, Colosseum Inlet and Rodds Bay. In contrast the nutrient scores remained the lowest-performing indicator group, particularly in The Narrows, Western Basin, Boat Creek and Boyne Estuary. Despite these localised nutrient pressures, water quality conditions remained stable overall.

Table 2 | Water quality sub-indicator and zone scores used in the 2026 Gladstone Harbour Report Card. Water quality scores are calculated by aggregation of physiochemical, nutrients and dissolved metals scores. Scores from previous assessments are shown for comparison.

Water quality	Physico chemical	Nutrients	Dissolved metals	2026	*2025*	*2024*
1. The Narrows	0.80	0.37	0.99	0.72	0.75	0.78
2. Graham Creek	0.94	0.51	1.00	0.82	0.80	0.90
3. Western Basin	0.78	0.38	0.99	0.72	0.76	0.80
4. Boat Creek	0.75	0.35	0.90	0.67	0.71	0.82
5. Inner Harbour	0.91	0.63	0.99	0.85	0.86	0.80
6. Calliope Estuary	0.87	0.54	1.00	0.80	0.88	0.82
7. Auckland Inlet	0.74	0.38	0.94	0.69	0.72	0.80
8. Mid Harbour	0.85	0.67	1.00	0.84	0.83	0.80
9. South Trees Inlet	0.87	0.50	0.97	0.78	0.79	0.84
10. Boyne Estuary	0.63	0.34	1.00	0.66	0.68	0.76
11. Outer Harbour	0.92	0.83	1.00	0.92	0.86	0.92
12. Colosseum Inlet	0.99	0.66	1.00	0.88	0.79	0.81
13. Rodds Bay	0.90	0.69	1.00	0.86	0.80	0.87
Harbour score	0.84	0.53	0.98	0.78	0.79	0.78

Sediment quality

Sediment quality retained a Very Good (A) grade and remained in a stable condition across Gladstone Harbour in 2026, with an overall harbour score of 0.96, unchanged from both 2025 and 2024 (Table 3). Scores were consistently high across all 13 monitoring zones, ranging from 0.91 to 1.00, indicating potential sediment contaminant concentrations remained well below guideline values. Several zones, including Colosseum Inlet, Boyne Estuary, Rodds Bay and Western Basin, achieved very high scores, while most other areas showed only minor year-to-year variation.

Table 3 | Sediment quality scores used in the 2026 Gladstone Harbour Report Card. Scores from previous assessments are shown for comparison.

Zone	2026	*2025*	*2024*
1. The Narrows	0.91	*0.91*	*0.91*
2. Graham Creek	0.95	*0.96*	*0.96*
3. Western Basin	0.98	*0.99*	*0.98*
4. Boat Creek	0.92	*0.91*	*0.91*
5. Inner Harbour	0.96	*0.95*	*0.93*
6. Calliope Estuary	0.98	*0.97*	*0.99*
7. Auckland Inlet	0.94	*0.93*	*0.95*
8. Mid Harbour	0.95	*0.96*	*0.96*
9. South Trees Inlet	0.96	*0.97*	*0.97*
10. Boyne Estuary	0.99	*0.98*	*0.97*
11. Outer Harbour	0.98	*0.97*	*0.98*
12. Colosseum Inlet	1.00	*1.00*	*1.00*
13. Rodds Bay	0.99	*0.96*	*0.97*
Harbour score	0.96	*0.96*	*0.96*

Habitats

Seagrass

Seagrass condition in Gladstone Harbour was assessed across 14 meadows spanning six monitoring zones. Three sub-indicators were used to evaluate condition: biomass (the amount of above-ground seagrass), area (the total extent of a meadow) and species composition (the relative proportions of seagrass species within each meadow).

Overall, Seagrass maintained a Good (B) grade in 2026, with an overall harbour score of 0.78. While this represents a slight decline from 0.81 in 2025, it remains well above the 2024 result of 0.68, continuing a broader trend of improving seagrass condition (Table 4). Seagrass biomass and meadow extent remained among the highest recorded since monitoring began, with 12 of the 14 monitored meadows graded Good (B) or Very Good (A).

Results varied among monitoring zones. The Narrows (0.92) and Rodds Bay (0.91) recorded the highest scores, supported by strong biomass, meadow area and species composition results. Western Basin improved from 0.78 in 2025 to 0.83 in 2026, while South Trees Inlet remained in good condition with a score of 0.83 despite a slight decline from the previous year. Inner Harbour recorded a zone score of 0.62 and remained unchanged from 2025, while Mid Harbour declined from 0.70 to 0.60, reflecting reduced meadow condition at monitored sites.

Table 4 | Seagrass sub-indicator, overall meadow and zone scores used in the 2026 Gladstone Harbour Report Card. Scores from previous assessments are shown for comparison.

Zone	Meadow	Biomass	Area	Species comp.	Overall meadow	2026	*2025*	*2024*
1. The Narrows	21	1.00	0.92	0.98	0.92	0.92	*0.99*	*0.89*
3. Western Basin	4	1.00	1.00	0.79	0.93	0.83	*0.78*	*0.70*
	5	1.00	0.96	0.88	0.92			
	6	0.92	0.90	0.55	0.72			
	7	0.81	0.77	1.00	0.77			
	8	0.97	0.81	0.66	0.73			
	52–57*	1.00	0.88	1.00	0.88			
5. Inner Harbour	58	0.87	0.81	0.43	0.62	0.62	*0.62*	*0.43*
8. Mid Harbour	43	0.50	0.81	0.84	0.50	0.60	*0.70*	*0.49*
	48	0.70	0.81	0.81	0.70			
9. South Trees Inlet	60	0.83	1.00	1.00	0.83	0.83	*0.88*	*0.81*
13. Rodds Bay	94	1.00	0.86	1.00	0.86	0.91	*0.89*	*0.74*
	96	1.00	1.00	0.99	1.00			
	104	1.00	0.86	1.00	0.86			
Harbour score						0.78	*0.81*	*0.68*

Note, the 2026 scores may differ slightly to those reported by Reason et al. (2026) due to bootstrapping.

Coral

Coral condition was assessed across six representative reefs in the Mid Harbour and Outer Harbour. Assessment was based on four sub-indicators: coral cover, macroalgal cover, juvenile coral density, and change in hard coral cover. Coral cover and macroalgal cover quantify the proportion of reef area occupied by living adult corals and macroalgae, while juvenile coral density measures the abundance of coral recruits (<5 cm). Change in hard coral cover was assessed using a three-year average rate of increase or decline. Together, these measures evaluate both the current state of coral reefs and their potential for recovery following disturbance.

Coral condition in Gladstone Harbour retained a Very Poor (E) grade in 2026, with the overall Coral indicator score increasing slightly from 0.09 in 2025 to 0.14 in 2026 and similar to 2024 (0.14) (Table 5). The modest improvement was driven by higher scores in the Mid Harbour, where reductions in macroalgae and small gains in coral cover contributed to improved scores. Despite these gains, overall harbour scores for coral cover (0.07), juvenile coral density (0.08) and coral recovery rates (0.15) remained low, indicating limited natural recovery and poor recruitment. Outer Harbour reefs continued to perform poorly, particularly for juvenile coral density, highlighting ongoing challenges for reef resilience. Long-term monitoring shows that coral communities remain well below historical condition, with recovery constrained by persistent environmental pressures and widespread macroalgae dominance.

Table 5 | Coral sub-indicator and zone scores used in the 2026 Gladstone Harbour Report Card. Scores from previous assessments are shown for comparison.

Zone	Coral cover	Macroalgal cover	Juvenile density	Change in hard coral cover	2026	*2025*	*2024*
8. Mid Harbour	0.08	0.50	0.10	0.30	0.24	*0.13*	*0.17*
11. Outer Harbour	0.07	0.00	0.06	0.06	0.03	*0.04*	*0.12*
Harbour score*	0.07	0.25	0.08	0.15	0.14	*0.09*	*0.14*

*Overall harbour scores an average of all six reef rather than average of zone scores.

Mangroves

Mangrove health was assessed using three sub-indicators: Extent, Canopy condition, and Shoreline condition. Extent measures the proportion of mangrove cover within tidal wetlands, while Canopy condition and Shoreline condition assess the condition of mangrove vegetation using satellite imagery and aerial photography. Mangroves were not assessed in 2026.

In the 2024 assessment, Mangroves received an overall score of 0.63, corresponding to a Satisfactory (C) grade (Table 6). This represents an improvement from 0.57 in 2019 and reflects generally stable to improving mangrove condition across the harbour. Six of the 13 reporting zones improved, four declined, and three remained unchanged. Improvements were largely driven by higher Canopy condition scores, which increased in eight zones and contributed positively to the overall harbour result. Mangrove extent remained high across most zones, while Shoreline condition showed greater variability among reporting zones.

Table 6 | Overall Mangrove sub-indicator and zone scores used in the 2026 Gladstone Harbour Report Card. Scores from previous assessments are shown for comparison.

Zone	Mangrove extent	Mangrove canopy condition	Shoreline condition	2026*	*2019*
1. The Narrows	0.73	0.76	0.39	0.63	*0.65*
2. Graham Creek	0.83	0.63	N/A	0.73	*0.64*
3. Western Basin	0.64	0.71	0.40	0.65	*0.51*
4. Boat Creek	0.72	0.70	0.54	0.65	*0.46*
5. Inner Harbour	0.40	0.63	0.55	0.56	*0.55*
6. Calliope Estuary	0.90	0.73	0.57	0.73	*0.58*
7. Auckland Inlet	0.67	0.72	0.03	0.47	*0.65*
8. Mid Harbour	0.19	0.59	0.88	0.49	*0.55*
9. South Trees Inlet	0.84	0.65	0.29	0.59	*0.60*
10. Boyne Estuary	0.62	0.48	0.88	0.66	*0.26*
11. Outer Harbour	0.72	0.66	0.68	0.68	*0.66*
12. Colosseum Inlet	0.88	0.60	0.44	0.64	*0.72*
13. Rodds Bay	0.79	0.62	0.78	0.73	*0.64*
Harbour score	0.69	0.65	0.53	0.63	*0.57*

N/A – Indicator not assessed due to insufficient data. *Results carried over from the 2024 assessment.

Fish and Crabs

Fish health

In 2026, Fish health received an overall score of 0.87 and a Very Good (A) grade. Fish health is calculated by the average of the harbour scores for two sub-indicators:

1. Fish condition: An automated visual assessment of images captured by fishers using a mobile phone app. Length and weight data were also recorded at the time of capture. Scores for Fish condition are based on two separate metrics; a visual assessment of fish health which includes skin, eyes, fins, parasites and deformities (visual fish condition) and an analysis of weight and length measures (fish body condition).

2. Fish Health Assessment Index (HAI): A thorough assessment of the health of individual fish based on visual condition and the condition of several internal organs and tissues.

Fish condition received a Very Good (A) grade in 2026, with an overall harbour score of 0.86, slightly lower than 2025 (0.90) (Table 7). All assessed species recorded very high visual fish condition scores (0.95–0.98), indicating low levels of disease, deformities and other visible health issues. While fish body condition varied among species and contributed to lower scores for some species, overall results indicate healthy fish populations. Species scores ranged from 0.74 for Barred Javelin to 0.95 for Dusky Flathead, with Yellowfin Bream, Pikey Bream and Mangrove Jack receiving Good (B) grades.

Fish HAI scored 0.88, corresponding to a Very Good (A) grade (Table 8). While this represents a slight decrease from 0.91 in 2025 and 0.90 in 2024, overall fish condition remains strong. Species level results showed Mullet achieved the highest score (1.00), improving on previous years, while Barred javelin maintained a Very Good (A) grade and high score (0.85) despite a small decline from 2025. Bream recorded a lower score (0.50) compared to recent years, contributing to the slight reduction in the harbour-wide result. Insufficient samples prevented scoring of Barramundi

and Blue catfish, but overall findings indicate fish populations remain in good health across the harbour.

Table 7 | Fish Condition measure and sub-indicator scores used in the 2026 Gladstone Harbour Report Card. Scores from previous assessments are shown for comparison.

Species	Visual fish condition	Fish body condition	2026	*2025*	*2024*
Yellowfin bream	0.97	0.72	0.85	*0.82*	*0.70*
Pikey bream	0.98	0.70	0.84	*0.85*	*0.81*
Barred javelin	0.96	0.52	0.74	*0.96*	*NC*
Dusky flathead	0.95	NC	0.95	*0.94*	*NC*
Mangrove jack	0.95	0.69	0.82	*0.94*	*0.84*
Harbour score			0.86	*0.90*	*0.78*

NC – Scores not calculated due to low sample size

Table 8 | Fish HAI sub-indicator scores used in the 2026 Gladstone Harbour Report Card. Scores from previous assessments are shown for comparison.

Species	2026	*2025*	*2021*
Bream	0.50	*0.85*	0.98
Barred javelin	0.85	*0.94*	0.90
Barramundi	NC	*NC*	0.98
Blue catfish	NC	*0.88*	0.81
Mullet	1.00	*0.98*	0.81
Harbour score	0.88*	*0.91*	0.90

NC – Individual species scores not calculated due to low sample size. *The overall harbour score is based on Fish HAI results across all species and does not represent the average of the individual species scores.

Fish recruitment

Fish recruitment was assessed for two species: Yellowfin bream *Acanthopagrus australis* and Pikey bream *A. pacificus*. Results declined from a Good (B) grade in 2025 (0.70) to a Satisfactory (C) grade in 2026 (0.58) (Table 9). Despite this decrease, the 2026 result is consistent with scores recorded in 2022 and 2024, suggesting recruitment remains within the range of natural year-to-year variability observed across the harbour.

Results varied among zones. Western Basin achieved the highest score (0.88), maintaining a Very Good (A) grade, while Boyne Estuary improved to 0.82 and achieved a Good (B) grade. In contrast, The Narrows (0.49), Graham Creek (0.44), South Trees Inlet (0.45) and Colosseum Inlet (0.46) recorded the lowest scores and received Poor (D) grades.

Table 9 | Fish recruitment indicator scores for each zone used in the 2026 Gladstone Harbour Report Card. Scores from previous assessments are shown for comparison.

Zone	2026	*2025*	*2024*	*2023*
1. The Narrows	0.49	*0.61*	*0.44*	*0.37*
2. Graham Creek	0.44	*0.68*	*0.54*	*0.53*
3. Western Basin	0.88	*0.89*	*0.82*	*0.77*
4. Boat Creek	N/A	*0.77*	*0.62*	*0.58*
5. Inner Harbour	0.56	*0.76*	*0.77*	*0.58*
6. Calliope Estuary	0.59	*0.65*	*0.50*	*0.28*
7. Auckland Inlet	0.59	*0.54*	*0.36*	*0.36*
8. Mid Harbour	0.59	*0.69*	*0.54*	*0.49*
9. South Trees Inlet	0.45	*0.63*	*0.39*	*0.31*
10. Boyne Estuary	0.82	*0.74*	*0.64*	*0.37*
12. Colosseum Inlet	0.46	*0.67*	*0.68*	*0.41*
13. Rodds Bay	0.55	*0.73*	*0.60*	*0.64*
Harbour score	0.58	*0.70*	*0.57*	*0.47*

N/A – Boat Creek sampling ceased in 2026 due to site access constraints.

Mud crab

Three mud crab sub-indicators were assessed across seven monitoring zones: abundance, sex ratio, and the prevalence of rust lesions. Abundance was estimated using catch per unit effort (CPUE), while sex ratio measured the proportion of legal-sized male crabs (>15 cm spine width) relative to legal-sized females. Rust lesion prevalence was calculated as the proportion of captured mud crabs exhibiting rust lesions.

The overall harbour score for Mud crabs remained stable over the past three years, increasing from 0.48 in 2024 to 0.54 in 2025 before declining slightly to 0.51 in 2026, maintaining a Satisfactory (C) grade (Table 10). Rodd Bay recorded one of its highest overall zone scores this year, driven by high sex ratio and rust lesion scores. In contrast, lower scores in the Inner Harbour and Auckland Inlet reflected localised pressures, particularly low crab abundance. Overall, 10 years of monitoring indicate that mud crab populations in Gladstone Harbour have remained stable, although condition continues to vary across monitoring zones and years.

Table 10 | Mud crab sub-indicator and indicator scores for the 2026 Gladstone Harbour Report Card. Scores from previous assessments are shown for comparison.

Zone	Abundance	Sex ratio	Prevalence of rust lesions	2026	*2025*	2024
1. The Narrows	0.84	0.57	0.51	0.64	*0.87*	*0.65*
2. Graham Creek	0.00	0.57	1.00	0.52	*0.35*	*0.31*
4. Boat Creek	1.00	0.05	0.85	0.63	*0.74*	*0.75*
5. Inner Harbour	0.00	0.00	0.48	0.16	*0.68*	*0.42*
6. Calliope Estuary	0.76	0.11	0.87	0.58	*0.27*	*0.38*
7. Auckland Inlet	0.00	0.62	0.32	0.31	*0.41*	*0.38*
13. Rodds Bay	0.08	1.00	1.00	0.69	*0.44*	*0.38*
Harbour score	0.38	0.42	0.72	0.51	*0.54*	*0.48*

Social

There was no new assessment of the Social component in 2026; the results were carried over from 2022. The overall Social score of 0.68 in 2022 was similar to the previous assessment in 2019 (0.67). This score was based on three indicator group scores: Harbour Usability (0.62), Harbour Access (0.68) and Liveability and Wellbeing (0.71) (Table 11). Since 2018, all indicator groups have received a Good (B) grade and the overall Social component has remained stable since 2015. These results suggest that in general Gladstone residents continue to feel that Gladstone Harbour provides a positive living experience and contributes to their quality of life.

Table 11 | Social Health indicator group and indicator scores used in the 2026 Gladstone Harbour Report Card. Scores from previous assessments are included for comparison.

Indicator group	Social indicators	2026*	2026*	*2019*	*2018*
Harbour Usability	Satisfaction with harbour recreational activities	0.73	0.62	*0.64*	*0.63*
	Perceptions of air and water quality	0.59			
	Perceptions of harbour safety for human use	0.55			
Harbour Access	Satisfaction with access to the harbour	0.75	0.68	*0.67*	*0.67*
	Satisfaction with boat ramps and public spaces	0.67			
	Perceptions of harbour health	0.63			
	Perceptions of barriers to access	0.69			
Liveability and Wellbeing	Liveability and wellbeing	0.71	0.71	*0.70*	*0.70*
Overall score			0.68	*0.67*	*0.67*

*No assessment was undertaken in 2026; results have carried over from the 2022 assessment

Cultural

The results for the Cultural component is based on the previous assessment undertaken in 2022. The overall score of 0.68 correspond to a Good (B) grade (Table 12). Sense of Place scores from the 2022 assessment suggests that the community expectations of the Gladstone Harbour area are being met. In 2025, Indigenous Cultural Heritage was removed from the Cultural component and is assessed separately under Section 7, Traditional Owner Values.

Table 12 | Sense of Place indicator and indicator group scores used in the 2026 Gladstone Harbour Report Card. Scores from previous assessments are shown for comparison.

Indicator group	Indicator	2026*	2026*	*2019*
Sense of Place	Place attachment	0.61	0.68	*0.65*
	Continuity	0.65		
	Pride in the region	0.76		
	Wellbeing	0.62		
	Appreciation of the harbour	0.84		
	Values	0.68		

*No assessment was undertaken in 2026; results have carried over from the 2022 assessment.

Economic

The Economic component achieved an overall score of 0.71, corresponding to a Good (B) grade, unchanged from 2025 (Table 13). Economic Performance remained strong, with a score of 0.85, supported by high tourism (0.90) and shipping activity (0.84) results. While shipping activity declined slightly from 0.89 in 2025, the port continued to be well utilised, indicating high levels of trade and shipping activity. Commercial fishing improved to 0.46, up from 0.19 in 2025, likely reflecting the inclusion of more complete and up-to-date fisheries data and providing a more representative assessment of commercial fishing activity in the region.

Economic Stimulus improved from 0.51 in 2025 to 0.59 in 2026, driven a by stronger employment score of 0.36 up from 0.20 in 2025. Socio-economic status remained very similar (0.76). Economic Value (recreation) maintained a score of 0.77, unchanged from previous assessments, highlighting the ongoing importance of recreational activities to the region. Scores for land-based recreation (0.79), recreational fishing (0.73), beach recreation (0.77) and water-based recreation (0.77) were carried forward from the 2022 assessment.

Table 13 | Economic Health indicator and indicator group scores used in the 2026 Gladstone Harbour Report Card. Scores from previous assessments are shown for comparison.

Indicator group	Indicators	2026	2026	*2025*	*2024*
Economic Performance	Shipping activity	0.84	0.85	*0.89*	*0.90*
	Tourism	0.90			
	Commercial fishing	0.46			
Economic Stimulus	Employment	0.36	0.59	*0.51*	*0.50*
	Socio-economic status	0.76			
Economic Value (recreation)	Land-based recreation^	0.79	0.77	*0.77*	*0.77*
	Recreational fishing^	0.73			
	Beach recreation^	0.77			
	Water-based recreation^	0.77			
Overall score			0.73	*0.71*	*0.74*

^No assessment was undertaken in 2026; results have carried over from 2022.

1 Introduction

1.1 The Gladstone Healthy Harbour Partnership

The Gladstone Healthy Harbour Partnership (GHHP) is a forum that brings together community, research, First Nations people, industry and all levels of Government to monitor the health of Gladstone Harbour. GHHP was formally launched in 2013 and released its first pilot Report Card in 2014. The GHHP vision is that 'Gladstone has a healthy, accessible, working harbour'. The guiding principles of the partnership are honest, transparent, accountable and easy to understand annual reporting of the health of Gladstone Harbour. Actions are based on rigorous science and strong stakeholder engagement.

The GHHP Management Committee is a sub-set of the broader Partnership with an operational role. It guides the management of the Partnership to meet its objectives on behalf of the Partners. The GHHP Independent Science Panel provides independent scientific advice, review and direction. Its role is to ensure that the environmental, social, cultural and economic challenges of policy, planning and actions, as they relate to achieving the GHHP vision, are supported by credible science.

The Gladstone Harbour Report Card reports on the Environmental, Social, Cultural and Economic health of the harbour (Figure 1.1). Stakeholder and community consultation identified these four components as important to the community during workshops conducted by GHHP in 2013.

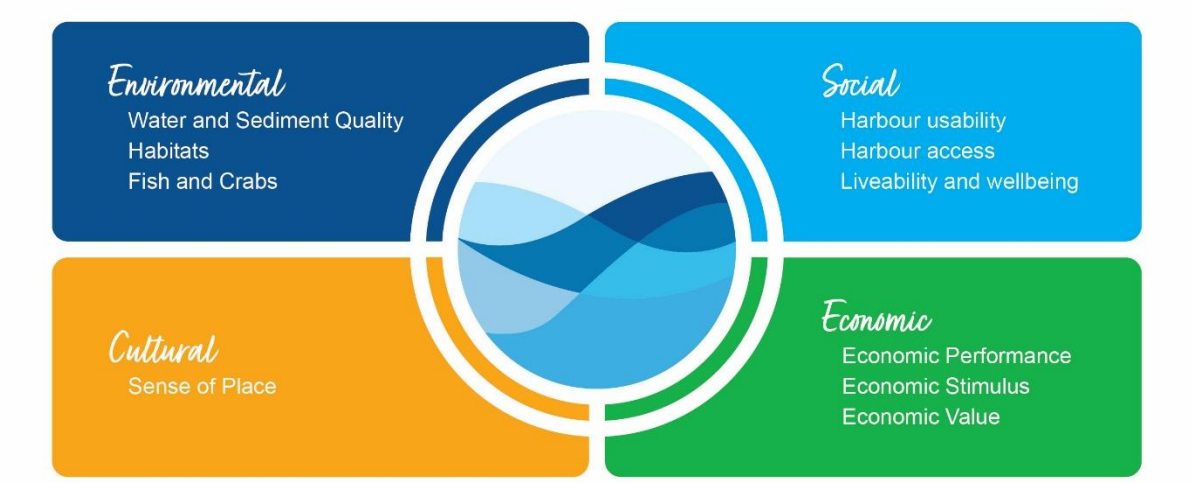

Figure 1.1 | The four components of assessment for Gladstone Harbour Report Card.

1.2 Report Card Monitoring

The 2026 report card showcases new monitoring data collected between 1 July 2025 and 30 June 2026. Over a decade of reporting has shown some indicators are stable each year, therefore no new assessments of Mangroves, Social and Cultural indicators were conducted in 2026; and results are carried over from previous report cards. The 2026 report card presents a partial assessment of the Economic indicators, with new assessment of Economic Performance and Economic Stimulus. The Economic Value results are repeated from the 2022 report card.

Environmental monitoring is conducted across 13 geographical zones in and around Gladstone Harbour: The Narrows, Graham Creek, Western Basin, Boat Creek, Inner Harbour, Calliope Estuary, Auckland Inlet, Mid Harbour, South Trees Inlet, Boyne Estuary, Outer Harbour, Colosseum Inlet and Rodds Bay. More information on each of these zones is available in Section 10 of this report.

2 From Indicators to Report Card Grades

2.1 Structure and Indicators

The hierarchy of score aggregation used to calculate the final grade for each component of harbour health can include up to five levels of aggregation: components, indicator groups, indicators, sub-indicators and measures (Table 2.1). This structure derives the final scores from raw data collected through field sampling, community surveys and publicly available sources.

Table 2.1 | The five levels of aggregation employed to determine the grades and scores in the 2026 Gladstone Harbour Report Card.

Name	Explanation
Level 1: Component	The report card reports on the condition of four components of harbour health: Environmental, Social, Cultural and Economic.
Level 2: Indicator group	Group of several related indicators – for instance, the indicator group 'Habitats' comprises the indicators Seagrass and Corals; the indicator group 'Economic Performance' comprises the indicators Shipping activity, Tourism and Commercial fishing.
Level 3: Indicator	An aspect of a system that may be used to indicate the state or condition of that system – for instance, 'Water quality and Seagrass' may be used to indicate the environmental condition of Gladstone Harbour; 'Shipping activity' may be used to indicate the economic state of Gladstone Harbour.
Level 4: Sub-indicator	Group of several related measures – for instance, the 'nutrients sub-indicator' (within water quality) comprises the measures total nitrogen, total phosphorus and chlorophyll-*a*.
Level 5: Measure	A numerical value assigned to an individual parameter used to assess harbour health. It may be based on a single measurement or combination of measurements for each parameter (e.g. an annual average).

Each indicator has a baseline and five ranges (A to E) that are used to calculate the grade for each measurement type. The methods used to determine baselines for each indicator are described in detail in the relevant sections of this report. Each threshold is a decimal value between 0.00 and 1.00 (Figure 2.1). Scores are assigned to measurements that are then aggregated upwards to the component level.

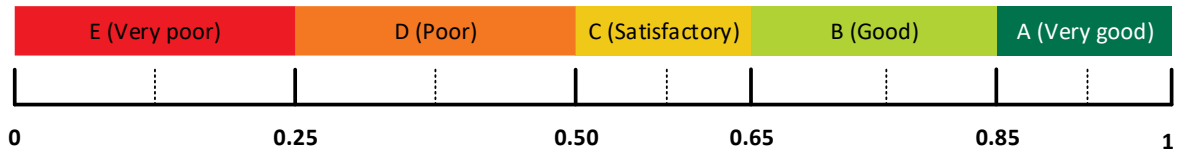

Figure 2.1 | Grade ranges used in the 2026 Gladstone Harbour Report Card.

2.2 Aggregation of report card grades and scores

A number of methods have been used to calculate an index value for the smallest geographic unit of reporting (e.g., 'site' for Water and Sediment Quality, 'reef' for Coral indicators and 'meadow' for Seagrass indicators) in the 2023–24 reporting period.

For example, the starting point for the Water Quality index calculation was the annual mean value for a measure per site. This was calculated by averaging the field data collected on four occasions in the 2023–24 reporting year. The annual site means were used to develop indexed scores between 0.00 and 1.00 compared with relevant guidelines (Figure 2.2) (Department of Environment and Heritage Protection (DEHP) Water Quality Objectives or Australia and New Zealand Guidelines default guideline values as appropriate - ANZG, 2018; DEHP, 2009). This yielded final indexed scores at site level which could be aggregated to higher levels of reporting (Figures 2.3–2.6). References have been provided on the methods used to calculate the indexed values for Coral, Seagrass, Mangroves and Fish and Crabs indicators in their respective sections in this report.

Aggregation used a hierarchical approach so that scores for a range of reporting levels (e.g. indicator, indicator group and component) could be generated for individual zones and for the whole harbour for reporting. The lowest level of reporting (e.g. measures such as aluminium, copper, lead, manganese, nickel and zinc for a site) was aggregated to the next level (e.g. metals in water) using bootstrapped distributions rather than direct means of each measure. The bootstrapping method resamples the original data many times to yield multiple means which are used to develop a series of distributions for measures, sub-indicators, indicators and indicator groups. By aggregating distributions (rather than individual means), the rich distributional properties could be preserved, sample bias could be avoided and means (the report card score) and variances could be calculated for reporting (Figure 2.7).

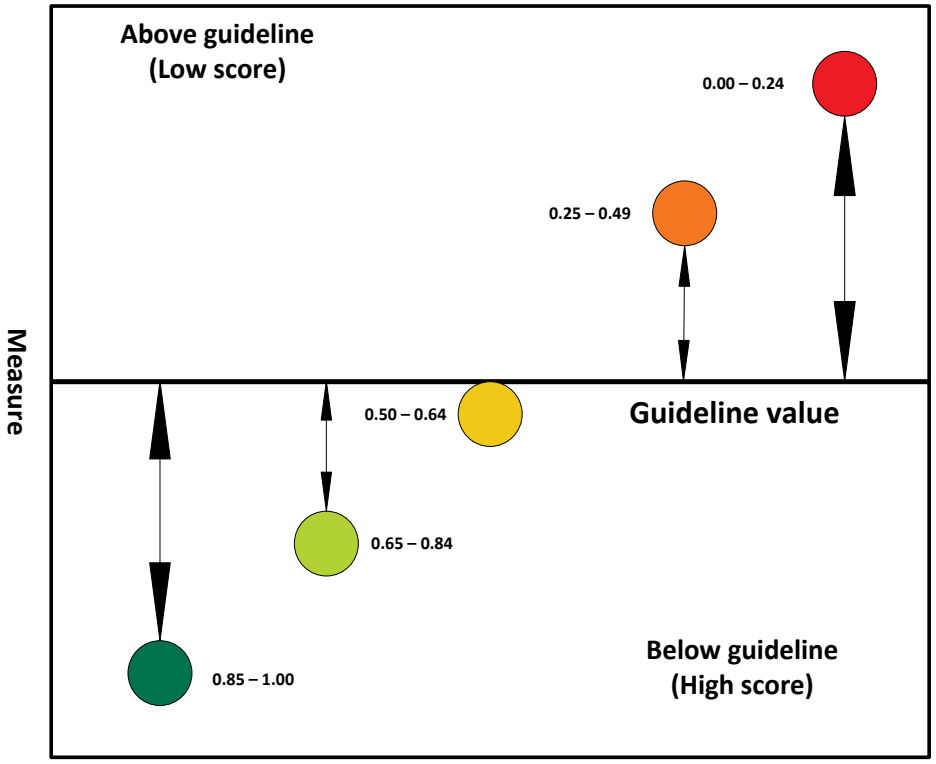

Figure 2.2 | Water and Sediment Quality measures are scored relative to zone and measure specific guideline values.

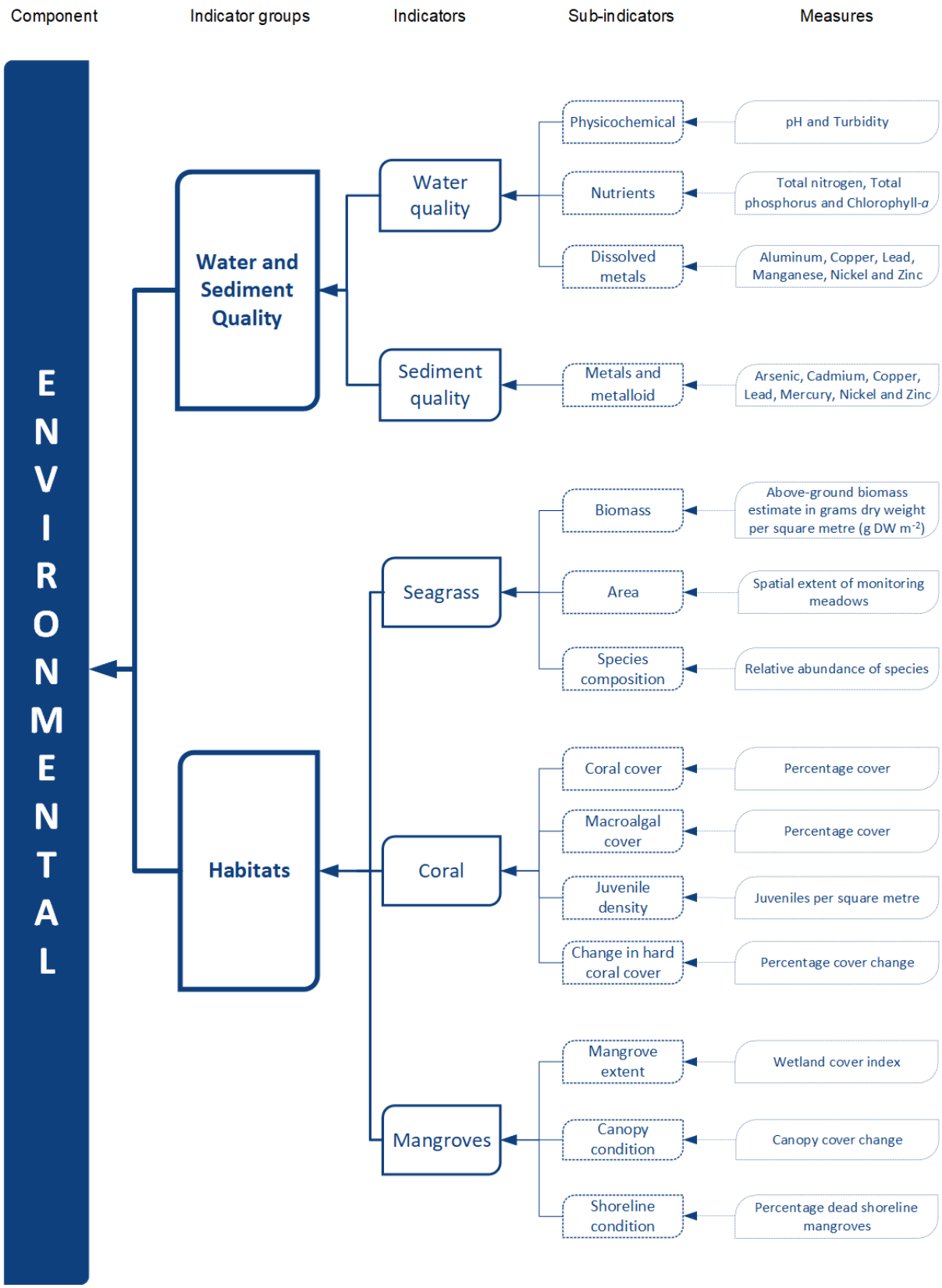

Figure 2.3a | The levels of aggregation used to determine the Environmental scores and grades in the 2026 Gladstone Harbour Report Card. There are three Environmental indicator groups, eight indicators, 19 sub-indicators and 47 measures.

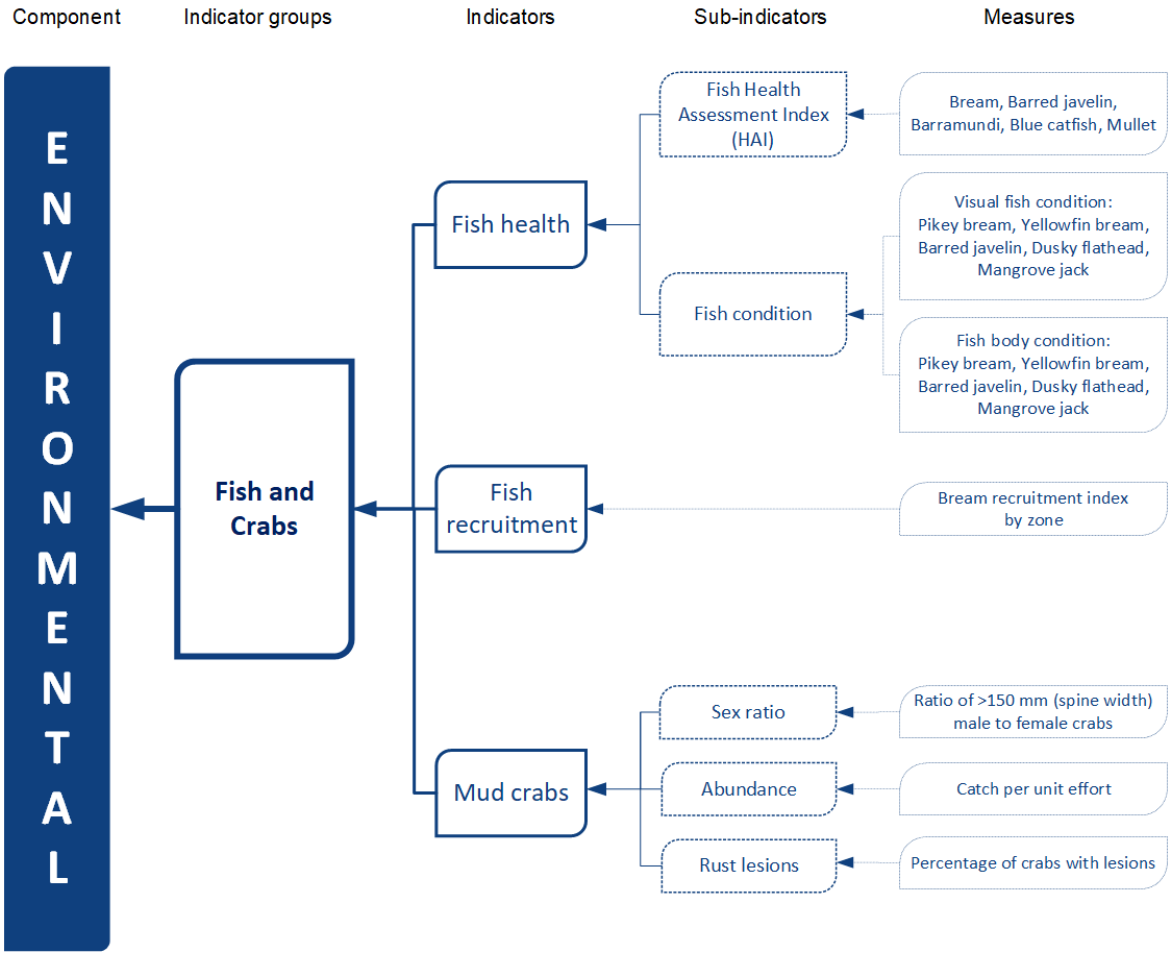

Figure 2.3b | The levels of aggregation used to determine the Environmental scores and grades in the 2026 Gladstone Harbour Report Card. There are three Environmental indicator groups, eight indicators, 19 sub-indicators and 47 measures.

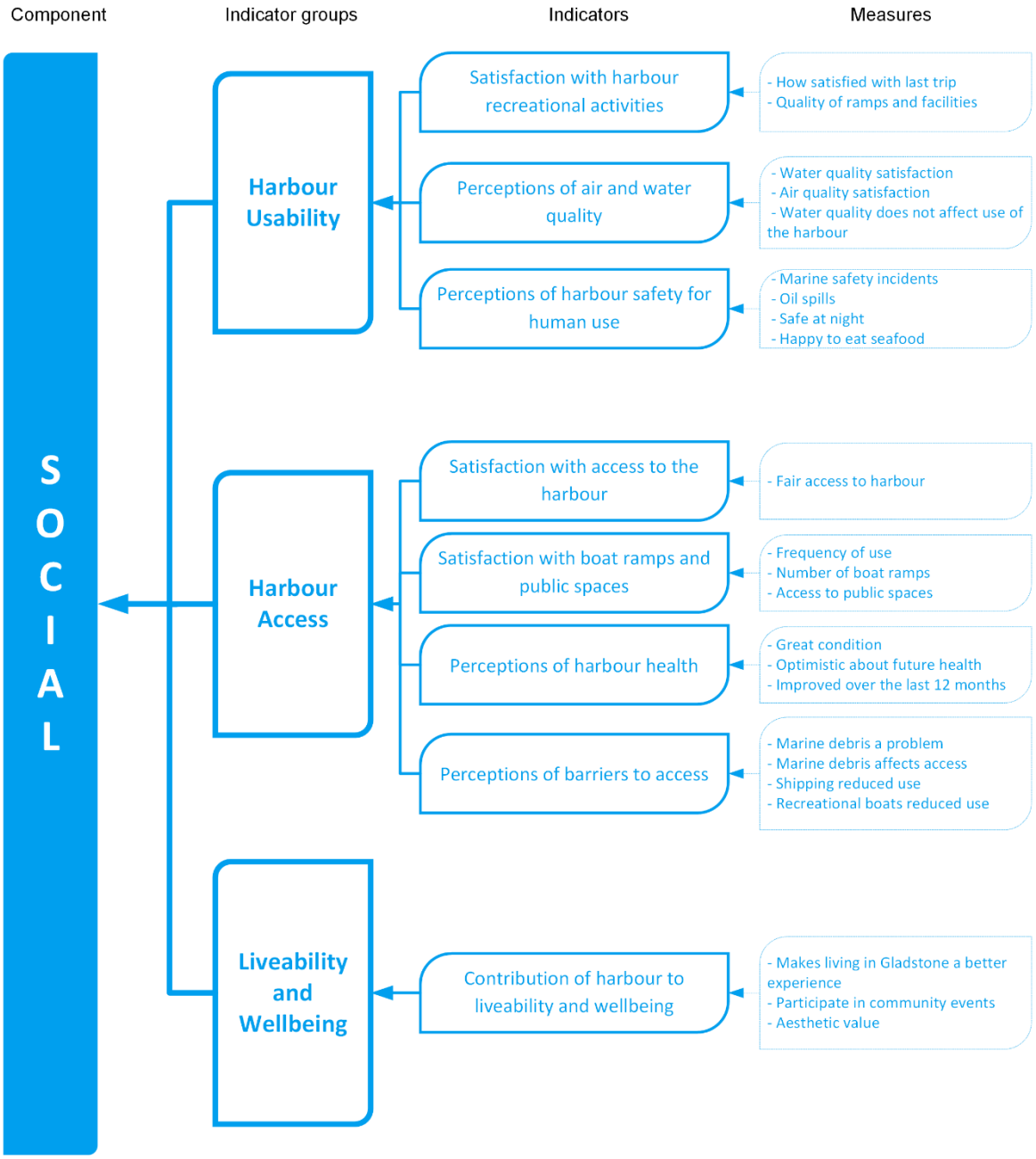

Figure 2.4 | The levels of aggregation used to determine the Social scores and grades in the 2026 Gladstone Harbour Report Card. There are three Social indicator groups, eight indicators and 23 measures.

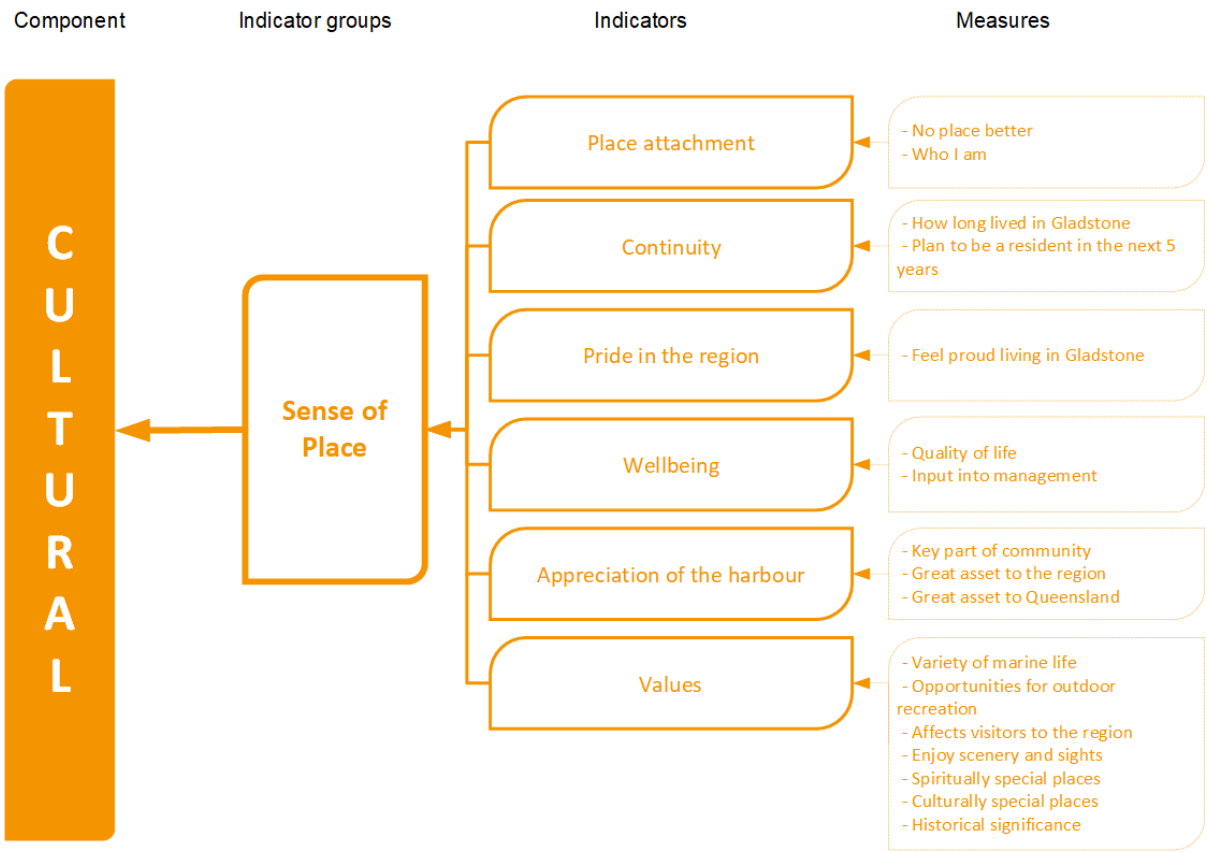

Figure 2.5 | The levels of aggregation used to determine the Cultural grades and scores in the 2026 Gladstone Harbour Report Card. There is one Cultural indicator group, six indicators and 17 measures.

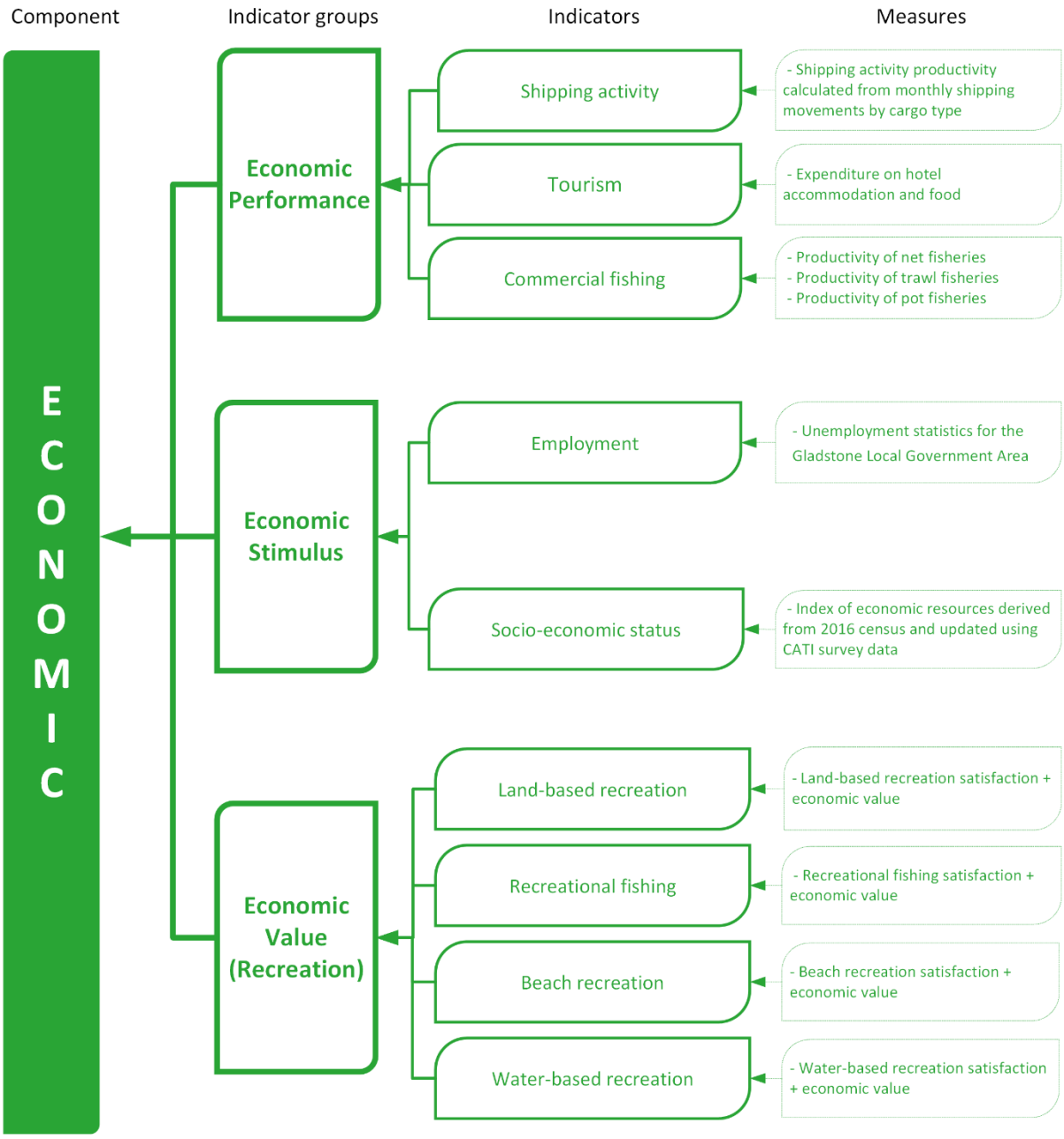

Figure 2.6 | The levels of aggregation used to determine the Economic scores and grades in the 2026 Gladstone Harbour Report Card. CATI: Computer-Assisted Telephone Interviewing. There are three Economic indicator groups, nine indicators and 11 measures.

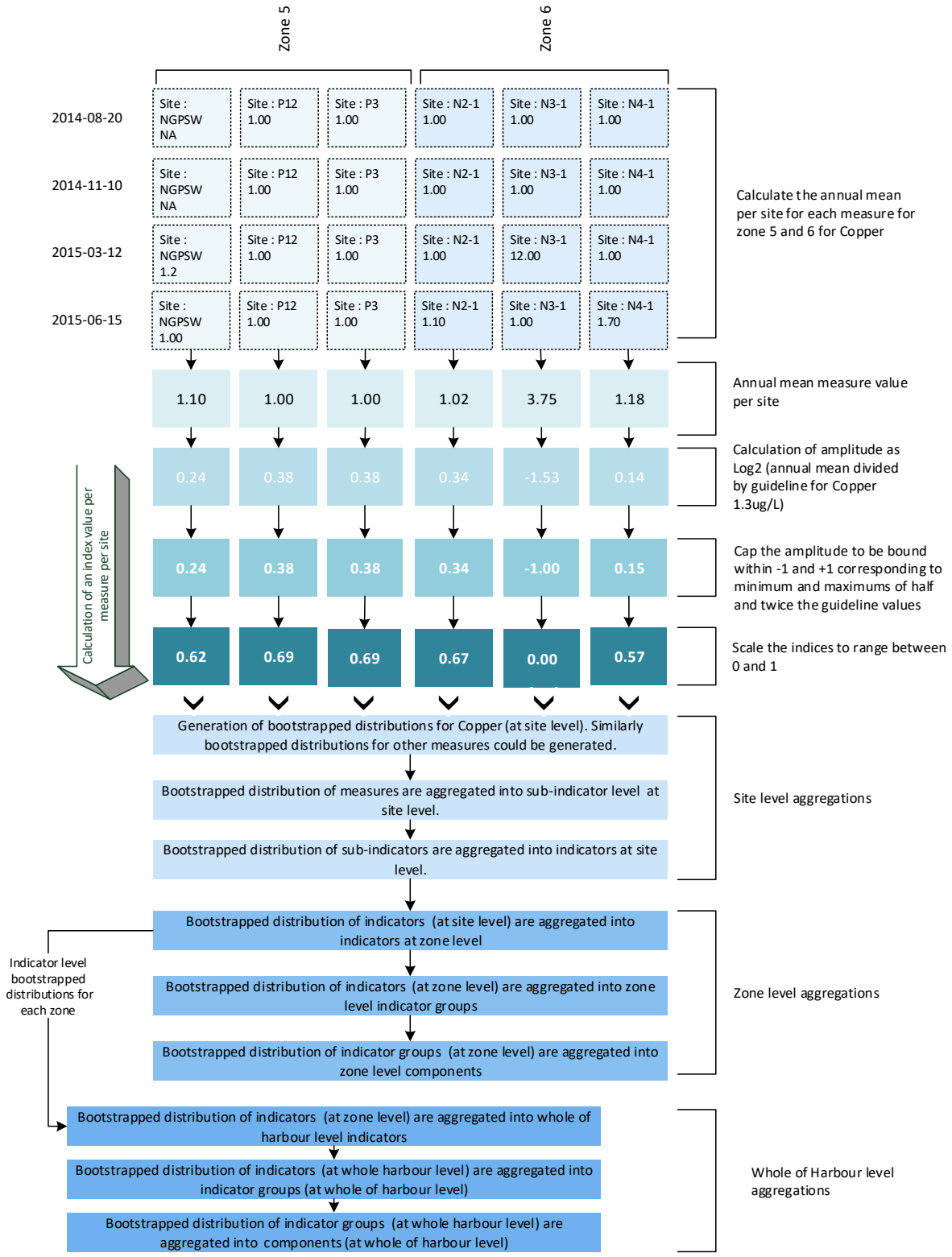

Figure 2.7 | Aggregation of report card scores – a worked example using the Water quality measure for copper in zones 5 and 6.

2.3 Confidence ratings

The GHHP Independent Science Panel have assigned confidence ratings for each indicator within the four components of the report card on a three-point scale (low, moderate and high). These ratings were informed by assessing the appropriateness of the indicators, the number of missing indicators, the adequacy of sampling designs and the availability, completeness and quality of the monitoring data.

Sediment quality, Seagrass, Corals, Fish recruitment, Fish health and Mud crabs indicators within the Environmental component all received high confidence ratings in 2026 (Table 2.2). This rating reflects that the indicators are appropriate, and additional years of data indicate the robustness of the methods used to determine the grades. Mangroves also received a high confidence rating in 2024, as a new assessment was completed in this reporting year. Water quality received moderate ratings.

Table 2.2 | Confidence ratings for individual Environmental indicators in 2026.

Indicator	Confidence	Reason
Water quality	Moderate	Exclusively, 'far-field' sites were reported on, and these were specifically sampled four times per year. Ongoing zinc and potential copper contamination issues.
Sediment quality	High	Appropriate methodology and sampling frequency, minimal laboratory issues since the pilot report card in 2014.
Seagrass	High	Consistent methods used over eight years of monitoring. Minor changes to scoring methods in 2018.
Corals	High	Consistent methods used over eight years of monitoring. Minor changes to scoring methods in 2018.
Mangroves	High	Upgraded to High as new assessment was completed in 2024.
Fish health	High	A new Fish HAI intensive assessment was completed in 2025. The two fish health projects had similar results.
Fish recruitment	High	Eight years of monitoring with consistent methods and data analysis. Minor change to sampling frequency in 2021.
Mud crabs	High	Seven years of monitoring with an appropriate methodology. The benchmarks are based on local populations. Minor changes to scoring methods in 2020.

The Social component received a moderate confidence rating in 2026. While the methodology was developed specifically for Gladstone Harbour and has remained largely unchanged since the Pilot Report Card in 2014, it is now outdated and does not align with the new Human Dimensions indicators currently under development. A revised framework is being developed and is expected to improve the assessment and reporting of social values from 2027 onwards.

The Cultural component also received a moderate confidence rating in 2026. Although the methodology used to assess Sense of Place is well established, it is based on a single survey dataset with no independent data sources available to validate the results. Future work to align the Cultural assessment with the new Human Dimensions framework is expected to improve confidence in this component.

The Economic component received a high confidence rating in 2026. The Computer Assisted Telephone Interview (CATI) survey was specifically designed for the Gladstone Harbour Report

Card and provides a reliable and repeatable method for assessing economic values. Additional data were sourced from reputable organisations and were considered suitable for reporting purposes. While some uncertainty remains around the definition of a tourist and the ability to distinguish the influence of Gladstone Harbour from Gladstone City within the Tourism indicator, the assessment was based on a complete set of indicators with no major issues relating to data availability, adequacy, or quality.

3 Environment

The health of Gladstone Harbour's Environment is assessed through three indicator groups: Water and Sediment Quality, Habitats and Fish and Crabs. Monitoring for all Environmental indicators occurred between 1 July 2025 and 30 June 2026, except Mangroves which were undertaken in May 2024.

3.1 Water and Sediment Quality

Water and Sediment Quality are important and interconnected aspects of the harbour ecosystem. A healthy water and sediment system sustains the health of a large number of aquatic species, including fish, turtles, dugongs, seagrass, mangroves and benthic invertebrates. Catchment-related, anthropogenic, climatic and other environmental factors play a major role in determining the Water and Sediment Quality recorded in the harbour. The GHHP Independent Science Panel recommended the measures for Water and Sediment Quality that are used in the report card, all of which have local or national guidelines.

For the Gladstone Harbour Report Card, Water Quality Objectives and guideline values were provided by:

- DEHP Water Quality Objectives for the Capricorn Curtis Coast (DEHP, 2014) for pH, turbidity and nutrients
- ANZG (2018) for metals in water and sediments (except aluminium)
- Golding et al. (2014) for aluminium in marine waters

The Water Quality Objectives used to calculate report card scores differed among geographic zones within Gladstone Harbour for all physicochemical and nutrient measures, but the guideline values were consistent for all metals.

The aluminium guidelines developed by Golding et al. (2014) and applied by DEHP (2014) ranged from 2.1 µg/L in high ecological value zones in Gladstone Harbour (The Narrows, Colosseum Inlet, Rodds Bay) to 24 µg/L in moderately disturbed zones (all other zones). This led to similar actual concentrations of aluminium being scored as very poor in high ecological value zones and very good in moderately disturbed zones. This created the misleading impression that the aluminium concentrations were far worse in high ecological value zones than in moderately disturbed zones. For this reason, the GHHP Independent Science Panel applied the moderately disturbed guideline of 24 µg/L across all zones for aluminium.

Since 2020, the GHHP Independent Science Panel has applied the guideline of 80 µg/L across all zones for manganese in marine waters consistent with ANZECC/ARMCAZ (2000).

The 95% species protection values from the ANZG (2018) water quality guidelines were applied to copper, lead, and zinc, while the 99% species protection value was applied to nickel. Water quality guideline values were selected for moderately disturbed systems.

Water and Sediment Quality data were collected in accordance with the following standards and procedures:

- Australian and New Zealand Standards for water quality and sediment sampling (AS/NZS 5667.1:1998; 5667.4:1998; 5667.6:1998; 5667.12:1998)
- American Public Health Association Standard Methods for the Examination of Water and Wastewater (APHA, 2005)
- Australian and New Zealand Water Quality Guidelines (ANZECC, 1992, 1998; ANZECC/ARMCANZ, 2000; ANZG, 2018)
- Queensland Water Quality Guidelines (DEHP, 2009)
- Department of Environment and Science Monitoring and Sampling Manual (DES, 2018)
- Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines (Simpson et al., 2013)

3.1.1 Water and Sediment Quality data collection

Water quality

Under a data-sharing agreement, the Port Curtis Integrated Monitoring Program (PCIMP) provided GHHP with water quality data to calculate scores for the 2026 report card. The data were collected from 51 sites across 13 harbour zones (Figures 11.1–11.27) during August and November 2025, and March and June 2026. The methods used in this section were provided by PCIMP (PCIMP, 2019).

Eleven water quality parameters were assessed: two physicochemical measures, three nutrient measures and six dissolved metals (Table 3.1). Physicochemical parameters were measured using a multi-parameter water quality sonde (YSI ProDSS), which was calibrated and checked prior to sampling. Measurements were taken at 0.5 m depth intervals through the water column until the seabed was reached. Triplicate sub-surface readings (0.5 m) were recorded at each site.

Water samples for nutrient and dissolved metal analyses were collected from a depth of 0.5 m using a Perspex pole sampler and a pre-acid washed Nalgene bottle (triple rinsed in Milli-Q and site water). Powder free gloves were worn to avoid contamination. Sample water was added directly to laboratory-provided sample bottles for total nitrogen, total phosphorous and chlorophyll-*a*. A sub-sample of water was filtered through a 0.45 µm membrane filter in the field for dissolved metals and dissolved nutrients. All samples were placed immediately on ice and dispatched to arrive at the nominated analysing laboratories within their recommended holding times. Field blanks, travel blanks and duplicate samples (at 20% of sites) were also collected and analysed in accordance with the standard protocols described above for laboratory and field quality assurance and quality control (QA/QC) purposes.

All analysing laboratories have been accredited by the National Association of Testing Authorities, Australia. This is to ensure compliance with relevant international and Australian standards and competency in providing consistently reliable testing, calibration, measurement, and inspection data. Dissolved metal samples were sent to the National Measurement Institute and nutrient samples were sent to the Queensland Health laboratories apart from chlorophyll-*a* samples, which were sent to Australian Laboratory Services. Field blanks, travel blanks and duplicate samples were dispatched to the same respective laboratories based on sample type.

Table 3.1 | Water quality sub-indicators and measures in the 2026 Gladstone Harbour Report Card.

Indicator	Sub-indicator	Measure	Guideline source
Water quality	Physicochemical	pH	DEHP, 2014
		Turbidity	DEHP, 2014
	Nutrients	Total nitrogen (TN)	DEHP, 2014
		Total phosphorus (TP)	DEHP, 2014
		Chlorophyll-*a*	DEHP, 2014
	Dissolved metals	Aluminium (Al)	Golding et al., 2014
		Copper (Cu)	ANZG, 2018
		Lead (Pb)	ANZG, 2018
		Manganese (Mn)	ANZG, 2018
		Nickel (Ni)	ANZG, 2018
		Zinc (Zn)	ANZG, 2018

See Appendix 2 for a full list of Water Quality Objectives and water quality guidelines.

Sediment quality

Six sediment metals and one metalloid (arsenic) were assessed (Table 3.2). Methods in this section were provided by PCIMP (PCIMP, 2019).

Sediment samples were collected from the same 51 harbour monitoring sites used for water quality sampling in May 2024. Grab samples were collected for sediment quality measures using a stainless steel Ponar grab sampler (0.008 m^3 volume). These samples were deposited into a collection tub that had been triple rinsed with seawater and then photographed. All sediment quality measurements used the top 100 mm of the sample, which were deposited into laboratory-provided sample containers using pre-acid-washed polypropylene trowels.

All sample containers were bagged and stored at 4°C and transported to the analysing laboratory, National Measurement Institute, within their recommended holding times. For field QA/QC, separate grabs were made for duplicate samples at 20% of sites.

Sediment nutrients were not included as there are no relevant national or international guidelines. They may be included in future report cards should relevant guidelines become available. Polycyclic aromatic hydrocarbons have not been included since the first report card owing to the extremely low concentrations recorded in 2015.

Table 3.2 | Sediment quality measures in the 2026 Gladstone Harbour Report Card.

Indicator	Sub-indicator	Measure	Guideline source
Sediment quality	Metals and metalloid	Arsenic (As)	ANZG, 2018
		Cadmium (Cd)	ANZG, 2018
		Copper (Cu)	ANZG, 2018
		Lead (Pb)	ANZG, 2018
		Mercury (Hg)	ANZG, 2018
		Nickel (Ni)	ANZG, 2018
		Zinc (Zn)	ANZG, 2018

See Appendix 3 for a full list of Sediment quality guidelines.

In October 2026, the GHHP Independent Science Panel discussed QA/QC issues with the raw dataset for 2026 for the water and sediment quality data collected.

Based on discussions, the GHHP Independent Science Panel recommended not to include NOx and orthophosphate measures in the report card analysis owing to the following issues:

1. Water Quality Objectives differ between zones, the application of the scoring created potentially perverse results (e.g., zones with the lowest Water Quality Objectives tended to have the lowest scores), and current limits of reporting for the laboratory analysis do not enable the lowest Water Quality Objectives to be assessed.

In 2026, the limit of reporting value for sediment mercury was at an acceptable level (0.01 mg/kg) compared to the guideline value (0.15 mg/kg). As such, the GHHP Independent Science Panel recommended to include sediment mercury in the report card analysis. Sediment mercury was included in previous years when the limit of reporting was at an acceptable level (e.g. 0.01 mg/kg in 2017, 2019 and 2021–24) and excluded in previous years when the limit of reporting was not at an acceptable level (e.g. 0.2 mg/kg in 2018 and 2020).

3.1.2 Water and Sediment Quality measures

A total of 18 Water and Sediment Quality measures were assessed and reported in the 2026 Gladstone Harbour Report Card. These measures were recommended by the GHHP Independent Science Panel as indicative of the factors relevant to the harbour and its condition. The importance of each measure to overall harbour health is described in the sections below.

Physicochemical indicators

pH

The pH of water is a measure of its alkalinity or acidity. By assessing the concentration of free hydrogen and hydroxyl ions in water, pH indicates whether the water is acidic (pH 0–6), neutral (7) or alkaline (pH 8–14). pH is an important property of marine and estuarine water as it determines the solubility and biological availability of many nutrients and metals. As a rule of thumb, the solubility of most metals tends to increase at low pH. Plant and animal species usually tolerate a narrow pH range outside of which their ecology and behaviour are adversely impacted.

Turbidity

Turbidity is a measure of water clarity and is affected by the levels of suspended sediment (sand, silt and clay), organic matter and plankton in the water. Coloured substances such as pigments and tannins from decaying plant matter may also reduce water clarity, but to a lesser extent. High turbidity decreases the light levels reaching the seabed which reduces photosynthesis and the production of dissolved oxygen. This can lead to suppressed growth and reproduction and if exposed to low light for prolonged periods, eventually to mortality of algae, seagrasses and corals.

Nutrients

Nitrogen (N) and phosphorus (P) are essential nutrients for all organisms and occur in the natural environment. However, excess concentrations of these nutrients in the marine environment may lead to increased biomass of phytoplankton, epiphytic algae and macro-algae which can have a range of negative effects. Phytoplankton blooms can be toxic, phytoplankton in the water column increases turbidity, and collapsing algal blooms deplete oxygen concentrations, causing fish kills and undesirable changes in sediment chemistry. Epiphytic algae and macroalgae can also kill or outcompete aquatic organisms such as seagrasses and corals that are important for habitat and foodwebs.

Total nitrogen

Total nitrogen is the sum of all forms of nitrogen in the marine environment, including nitrate, nitrite, ammonia nitrogen and organic nitrogen. Nitrogen is an essential nutrient for all organisms, but at high levels it can lead to the problems described above.

Total phosphorus

In aquatic systems, phosphorus exists in various forms such as dissolved orthophosphate, organic phosphorus and particulate phosphorus. The total phosphorus measure gives an indication of all forms of phosphorus in the water body. Key sources of phosphorus in water include urban run-off, fertiliser run-off, rock weathering, sewage effluent and animal faeces.

Chlorophyll-*a*

Chlorophyll-*a* is a plant pigment used in photosynthesis. Chlorophyll-*a* measured in the water is an indication of concentrations of phytoplankton growth (pelagic microalgae and cyanobacteria) which is related to dissolved nutrient concentrations. High levels of chlorophyll-*a* may indicate presence of elevated nutrient concentrations and potentially, algal or cyanobacterial algal blooms.

Dissolved metals and metalloid

A suite of metals and one metalloid (arsenic) have been selected as indicators of harbour health. General information on the descriptions of metals, factors affecting toxicity and toxicology were retrieved from ANZG (2018).

Aluminium
The element aluminium (Al) is a silvery white metal and the most abundant metal in the Earth's crust (Zumdahl and DeCost, 2010); therefore, it is common to find traces of this element in soil, sediment and water. Aluminium in seawater can be derived from sources that are natural (e.g., weathering of mineral rocks) or anthropogenic (e.g., mining waste, industrial discharges, urban run-off). High levels of dissolved aluminium in aquatic systems are toxic to algae and marine animals.

Arsenic
Arsenic (As) is a naturally occurring element in the environment. It can be introduced into aquatic environments through natural contamination (e.g., by geothermal activity) or anthropogenically, principally through mining-related activities that may disturb arsenic deposits (Garelick et al., 2008). Arsenic may also be mobilised from bauxite residues remaining after aluminium extraction and is typically stored in red mud dams (Lockwood et al., 2014). In sediment, arsenic is available as As (III), As (V) and in methylated forms. It is a highly soluble and mobile element, inorganic forms of which may be toxic to aquatic species. Most biota convert inorganic arsenic to less toxic organic forms (e.g., arsenosugars, arsenobetaine).

Cadmium
Cadmium (Cd) is a non-essential element in plants and animals. The sources of cadmium in oceanic waters may be natural (e.g., volcanic activities, rock weathering) or anthropogenic (e.g. releases from open burning or incineration of municipal waste, mining activities, releases from landfills). In water, cadmium is mostly adsorbed onto sediment and suspended particles. Increased concentrations of cadmium in aquatic systems can lead to a range of toxic effects in fish, invertebrates, amphibians and aquatic plants (UNEP, 2010).

Copper
Copper (Cu) is an essential micro-nutrient for plants and animals. As for other metals, sources of copper in water may be natural (e.g., released from sediments) or anthropogenic (e.g., as a biocide in antifouling marine paint). Increased concentrations of copper in aquatic systems can lead to a range of toxic effects on algae, invertebrates, fish, and other animals.

Lead
Lead (Pb) is a toxic heavy metal that may have anthropogenic (e.g., industrial discharge, mining discharge) or natural origins. Natural waters generally have very low concentrations of lead. In water, lead is mostly adsorbed onto sediment and suspended particles. This metal has no known benefits to aquatic plants or animals. In marine environments, increased lead can disrupt invertebrate growth and therefore affect populations (Botte et al., 2022).

Manganese
Manganese (Mn) is the 11th most abundant element in the Earth's crust and an essential nutrient for the wellbeing of plants and animals. Its origin can be either anthropogenic or natural. The overall toxicity of manganese to marine biota (except corals) is low. Two manganese deposits near Gladstone Harbour have previously been mined and produced over 1,000 tonnes of manganese ore. Those deposits were at Auckland Inlet (mined 1882–1900) and Boat Creek (mined 1901–1902) (Wilson and Anastasi, 2010).

Mercury
Mercury (Hg) is a toxic heavy metal that can have natural (e.g. weathering of rocks over time) or anthropogenic origins (e.g. coal burning power stations). In sediments it can be converted to methylmercury by microorganisms. This highly toxic chemical can build up in shellfish, fish and

animals that eat fish. Potential effects of mercury exposure include a reduction in growth rate and development, abnormal behaviour and death.

Nickel

Nickel (Ni) is the 24th most abundant metal in the Earth's crust and is essential for all organisms (Cempel and Nikel, 2006). Nickel in waterways can come from sources that are industrial or natural (e.g., through rock weathering). In water, nickel is mostly adsorbed onto sediment and suspended particles. At high concentrations, nickel becomes toxic to organisms, but it does not tend to bioaccumulate through the food web.

Zinc

Zinc (Zn) is an essential trace element for animals and plants. Anthropogenic sources include zinc from sacrificial anodes in ships, industrial discharges (e.g., mines, galvanic industries, and battery production), sewage effluent, surface run-off and some fungicides and insecticides. At high concentrations zinc is toxic to organisms.

3.1.3 Water and Sediment Quality results

Water quality

Water quality maintained a Good (B) grade in 2026, with an overall harbour score of 0.78, representing a slight improvement from 0.75 in 2025 and matching the score achieved in 2024 of 0.78 (Table 3.3). Strong performance was driven by consistently high scores for dissolved metals (0.98) and physicochemical measures (0.84), while the nutrient sub-indicator remained the lowest scoring group (0.53) influencing the overall water quality results.

Spatially, all zones achieved Good (B) or Very Good (A) grades. Water quality scores ranged from 0.66 in Boyne Estuary to 0.92 in Outer Harbour, with score improvements observed from 2025 in the Outer Harbour (+0.06), Colosseum Inlet (+0.09) and Rodds Bay (+0.06).

Table 3.3 | Water quality sub-indicator and zone scores used in the 2026 Gladstone Harbour Report Card.

Water quality	Physico chemical	Nutrients	Dissolved metals	2026	*2025*	*2024*
1. The Narrows	0.80	0.37	0.99	0.72	0.75	0.78
2. Graham Creek	0.94	0.51	1.00	0.82	0.80	0.90
3. Western Basin	0.78	0.38	0.99	0.72	0.76	0.80
4. Boat Creek	0.75	0.35	0.90	0.67	0.71	0.82
5. Inner Harbour	0.91	0.63	0.99	0.85	0.86	0.80
6. Calliope Estuary	0.87	0.54	1.00	0.80	0.88	0.82
7. Auckland Inlet	0.74	0.38	0.94	0.69	0.72	0.80
8. Mid Harbour	0.85	0.67	1.00	0.84	0.83	0.80
9. South Trees Inlet	0.87	0.50	0.97	0.78	0.79	0.84
10. Boyne Estuary	0.63	0.34	1.00	0.66	0.68	0.76
11. Outer Harbour	0.92	0.83	1.00	0.92	0.86	0.92
12. Colosseum Inlet	0.99	0.66	1.00	0.88	0.79	0.81
13. Rodds Bay	0.90	0.69	1.00	0.86	0.80	0.87
Harbour score	0.84	0.53	0.98	0.78	0.75	0.78

The physicochemical sub-indicator achieved a harbour score of 0.84. pH recorded the highest possible score (1.00) across all monitoring zones, demonstrating stable water quality conditions throughout the harbour (Table 3.4). Turbidity showed greater spatial variability, with lower scores recorded in Boat Creek (0.51), Auckland Inlet (0.47) and Boyne Estuary (0.27), while Graham Creek (0.88) and Colosseum Inlet (0.98) achieved the highest scores.

Nutrients remained the lowest scoring water quality sub-indicator, with a harbour score of 0.53. Total phosphorus performed well overall (0.70), while lower scores for total nitrogen (0.47) and particularly chlorophyll-a (0.40) reduced the overall nutrient result. Chlorophyll-a scores were notably low in The Narrows (0.14), Graham Creek (0.14), Western Basin (0.13) and Boyne Estuary (0.24), indicating elevated algal biomass relative to guideline values. In contrast, Outer Harbour achieved the highest nutrient score (0.83) and the highest overall water quality score (0.92) of all monitoring zones.

Dissolved metals achieved a very high overall harbour score of 0.98, indicating that concentrations remained well below guideline values. Aluminium, lead, nickel and zinc recorded harbour scores the highest possible score (1.00), while manganese also performed strongly (0.99). Copper was the only dissolved metal to show lower scores at some locations, particularly in Boat Creek (0.45), Auckland Inlet (0.75) and South Trees Inlet (0.83), although dissolved metals overall continued to indicate very good water quality conditions throughout the harbour.

Table 3.4 | Water quality measure scores used in the 2026 Gladstone Harbour Report Card.

Zone	Physicochemical		Nutrients			Dissolved metals					
	pH	Turbidity	Total N	Total P	Chl-*a*	Al	Cu	Pb	Mn	Ni	Zn
1. The Narrows	1.00	0.60	0.45	0.52	0.14	1.00	0.96	1.00	1.00	1.00	1.00
2. Graham Creek	1.00	0.88	0.47	0.90	0.14	1.00	1.00	1.00	1.00	1.00	1.00
3. Western Basin	1.00	0.57	0.41	0.59	0.13	1.00	0.97	1.00	1.00	1.00	1.00
4. Boat Creek	1.00	0.51	0.32	0.27	0.46	1.00	0.45	1.00	0.94	1.00	1.00
5. Inner Harbour	1.00	0.83	0.57	0.92	0.40	1.00	0.97	1.00	1.00	1.00	1.00
6. Calliope Estuary	1.00	0.75	0.42	0.61	0.58	1.00	1.00	1.00	1.00	1.00	1.00
7. Auckland Inlet	1.00	0.47	0.32	0.40	0.41	1.00	0.75	1.00	0.92	1.00	0.99
8. Mid Harbour	1.00	0.71	0.58	0.85	0.58	1.00	1.00	1.00	1.00	1.00	1.00
9. South Trees Inlet	1.00	0.74	0.52	0.72	0.25	1.00	0.83	1.00	1.00	1.00	1.00
10. Boyne Estuary	1.00	0.27	0.35	0.44	0.24	1.00	1.00	1.00	1.00	1.00	1.00
11. Outer Harbour	1.00	0.84	0.61	1.00	0.88	1.00	1.00	1.00	1.00	1.00	1.00
12. Colosseum Inlet	1.00	0.98	0.51	0.97	0.48	1.00	1.00	1.00	1.00	1.00	1.00
13. Rodds Bay	1.00	0.80	0.61	0.95	0.50	1.00	1.00	1.00	1.00	1.00	1.00
Harbour score	1.00	0.69	0.47	0.70	0.40	1.00	0.92	1.00	0.99	1.00	1.00
Indicator score	0.84		0.53			0.98					

Total N – total nitrogen; Total P – total phosphorous; Chl-*a* – chlorophyll-*a*; Al – aluminium; Cu – copper; Pb – lead; Mn – manganese; Ni – nickel; Zn – zinc.

Sediment quality

In 2026, overall harbour Sediment quality achieved a Very Good (A) grade and the same score as 2025 of 0.96 (Table 3.5).

Cadmium, lead, mercury and zinc recorded scores of 1.00 across all zones, while copper scores were also consistently high, with only a slight reduction in Calliope Estuary (0.98) and Auckland Inlet (0.99). Arsenic and nickel were the only measures to show notable spatial variation. Arsenic scores ranged from 0.67 in the Mid Harbour to 1.00 in the Calliope Estuary, resulting in an overall harbour score of 0.85. Lower arsenic scores were also recorded in The Narrows (0.69) and Boat Creek (0.71). Nickel scores ranged from 0.60 in The Narrows to 1.00 in several zones, including Mid Harbour, Boyne Estuary, Outer Harbour, Colosseum Inlet and Rodds Bay. Lower nickel scores were observed in Graham Creek (0.85), Boat Creek (0.67) and Auckland Inlet (0.72), contributing to an overall harbour score of 0.88.

Despite some localised variation in arsenic and nickel, sediment quality was consistently high across the harbour, with all other metals and metalloids achieving maximum scores and indicating very good sediment quality conditions in 2026.

Table 3.5 | Sediment quality scores used in the 2026 Gladstone Harbour Report Card.

	Metals and metalloid								
Zone	As	Cd	Cu	Pb	Hg	Ni	Zn	**2026**	***2025***
1. The Narrows	0.80	1.00	1.00	1.00	1.00	0.60	1.00	0.91	*0.91*
2. Graham Creek	0.81	1.00	1.00	1.00	1.00	0.83	1.00	0.95	*0.96*
3. Western Basin	0.92	1.00	1.00	1.00	1.00	0.91	1.00	0.98	*0.99*
4. Boat Creek	0.76	1.00	1.00	1.00	1.00	0.67	1.00	0.92	*0.91*
5. Inner Harbour	0.80	1.00	1.00	1.00	1.00	0.94	1.00	0.96	*0.95*
6. Calliope Estuary	1.00	1.00	0.98	1.00	1.00	0.91	1.00	0.98	*0.97*
7. Auckland Inlet	0.84	1.00	0.99	1.00	1.00	0.72	1.00	0.94	*0.93*
8. Mid Harbour	0.67	1.00	1.00	1.00	1.00	1.00	1.00	0.95	*0.96*
9. South Trees Inlet	0.85	1.00	1.00	1.00	1.00	0.88	1.00	0.96	*0.97*
10. Boyne Estuary	0.90	1.00	1.00	1.00	1.00	1.00	1.00	0.99	*0.98*
11. Outer Harbour	0.84	1.00	1.00	1.00	1.00	1.00	1.00	0.98	*0.97*
12. Colosseum Inlet	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00	*1.00*
13. Rodds Bay	0.93	1.00	1.00	1.00	1.00	1.00	1.00	0.99	*0.96*
Harbour score	0.85	1.00	1.00	1.00	1.00	0.88	1.00	0.96	*0.96*

As – arsenic, Cd – cadmium, Cu – copper, Pb – lead, Hg – mercury, Ni – nickel and Zn – zinc.

3.1.4 Water and Sediment Quality discussion

The 2026 results demonstrate that water quality conditions across Gladstone Harbour remained generally healthy, with strong performance for dissolved metals and physicochemical measures indicating that most Water Quality Objectives continued to be met. Consistently high dissolved metal scores suggest that metal concentrations remained well below levels expected to pose risks to aquatic ecosystems. Similarly, the continued strong performance of sediment quality indicators reflects generally low contaminant concentrations and favourable sediment conditions across the harbour.

Notably, nutrients remained the primary factor influencing water quality performance in 2026. While total phosphorus scores were generally high across the harbour, lower total nitrogen and chlorophyll-a scores indicate that nutrient enrichment continues to occur in some areas. Elevated chlorophyll-a concentrations suggest increased phytoplankton biomass and may reflect greater nutrient availability. Spatial patterns showed a clear contrast between upper-harbour and estuarine environments, including The Narrows, Western Basin, Boat Creek and the Boyne Estuary, which recorded lower nutrient scores, and the Outer Harbour, where stronger scores likely reflected greater water exchange and dilution with offshore waters. Nutrient concentrations within Gladstone Harbour are influenced by a range of factors, including catchment runoff, land use, industrial discharges, climatic conditions, and the resuspension of nutrient-rich sediments. Although rainfall and river discharge were generally below average during the reporting period, these processes continue to shape nutrient dynamics and algal productivity across the harbour.

Angel et al. (2012) reported that particulate arsenic concentrations exceeded the ANZECC/ARMCANZ Interim Sediment Quality Guideline (ISQG)-Low trigger value in two samples from The Narrows and one sample near Quoin Island. The authors concluded that these elevated arsenic concentrations were associated with natural geological formations in the area rather than anthropogenic inputs. Similarly, previous studies have suggested that The Narrows is a natural source of dissolved nickel, with dissolved nickel concentrations increasing in waters closer to this region (Angel et al., 2010; Angel et al., 2012). A similar pattern was evident in sediment nickel scores reported in both the current and previous Gladstone Harbour Report Cards, further supporting the interpretation of a natural source of nickel.

Overall, the results indicate that water and sediment quality in Gladstone Harbour remained in very good condition in 2026. However, the continuing influence of nutrients, particularly total nitrogen and chlorophyll-a, highlights the importance of ongoing monitoring to better understand nutrient sources, spatial patterns and potential long-term implications for ecosystem health.

3.1.5 Water and Sediment Quality trends

Water quality indicator and sub-indicators

Scores for the Water quality indicator have remained high since the first full report card in 2015 resulting in Good (B) or Very Good (A) grades (Figure 3.1).

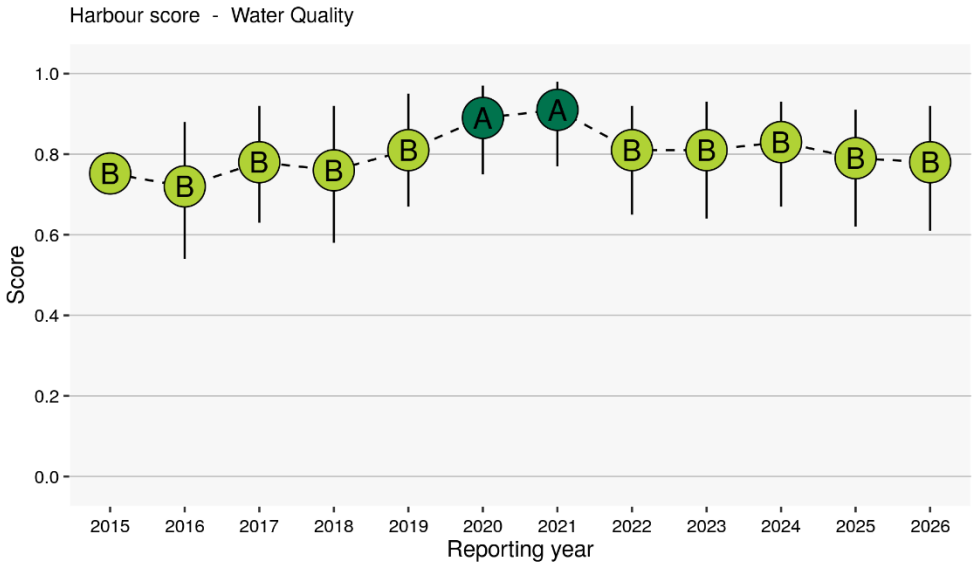

Figure 3.1 | Trends in the overall harbour score for Water quality physicochemical sub-indicator 2016–2026 (Error bars show 95% bootstrap confidence intervals).

Physicochemical water quality has remained consistently strong throughout the monitoring period (Figure 3.2). Scores improved from a Good (B) grade in 2016 (0.68) to Very Good (A) grades in 2018, 2020 and 2021, reflecting favourable conditions for measures pH and turbidity. Since 2022, scores have remained stable within the Good (B) grade range.

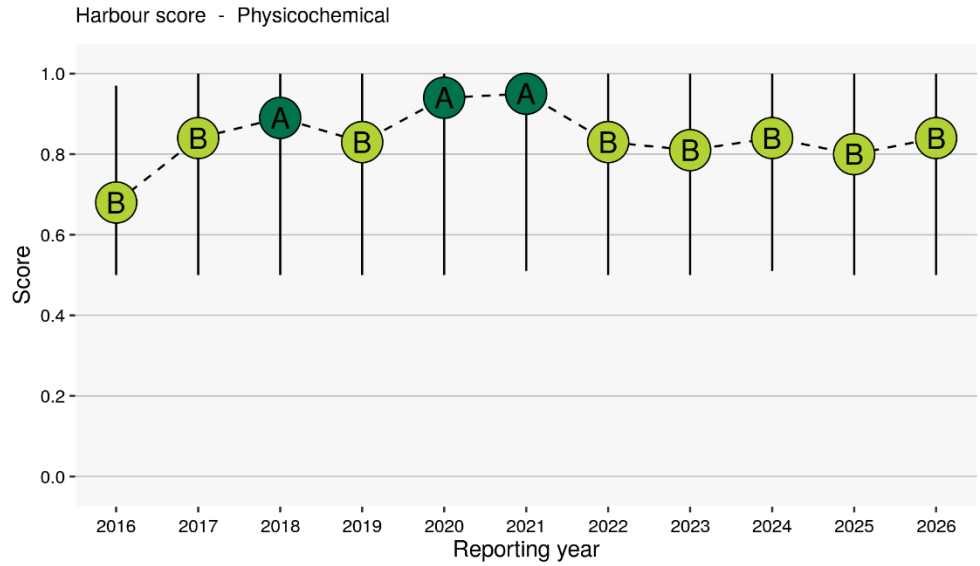

Figure 3.2 | Trends in the overall harbour score for Water quality physicochemical sub-indicator 2016–2026 (Error bars show 95% bootstrap confidence intervals).

Nutrient condition has fluctuated over the reporting period, generally remaining within the Satisfactory (C) grade range (Figure 3.3). Scores improved between 2018 and 2021, peaking at a Good (B) grade in 2021 (0.79), before declining and stabilising at lower levels from 2022 onwards. The 2026 score of 0.53 indicates nutrient concentrations needs monitoring, with recent results

suggesting a gradual downward trend compared to the strong performance observed in 2020 and 2021.

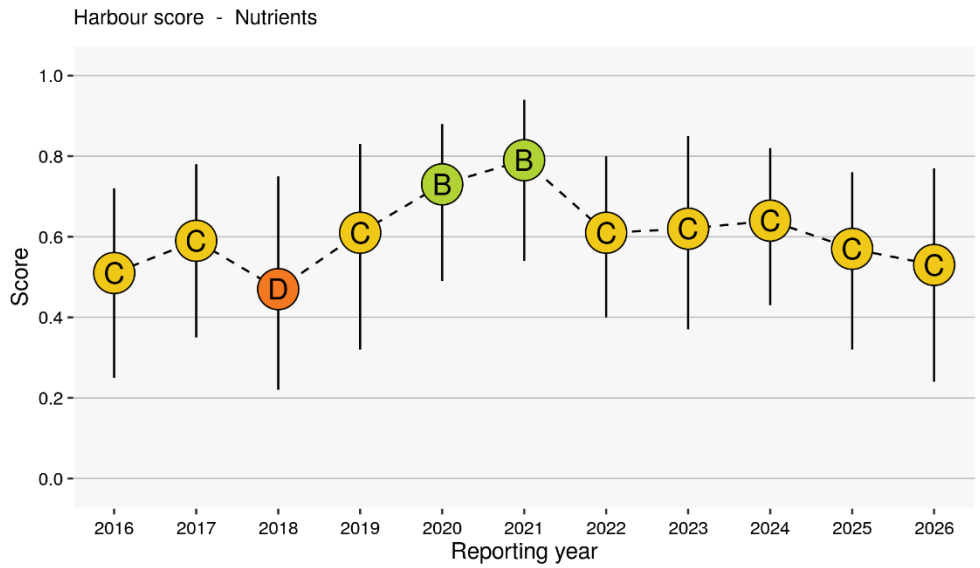

Figure 3.3 | Trends in the overall harbour score for Water quality nutrient sub-indicator 2016–2026 (Error bars show 95% bootstrap confidence intervals).

Dissolved metals have consistently achieved Very Good (A) grades throughout the entire reporting period, representing the strongest and most stable water quality sub-indicator (Figure 3.4). Scores have remained close to 1.0 since 2019, indicating dissolved metal concentrations have consistently remained well below guideline values. The 2026 score of 0.98 continues this long-term pattern of excellent performance, with minimal variation observed over the past decade.

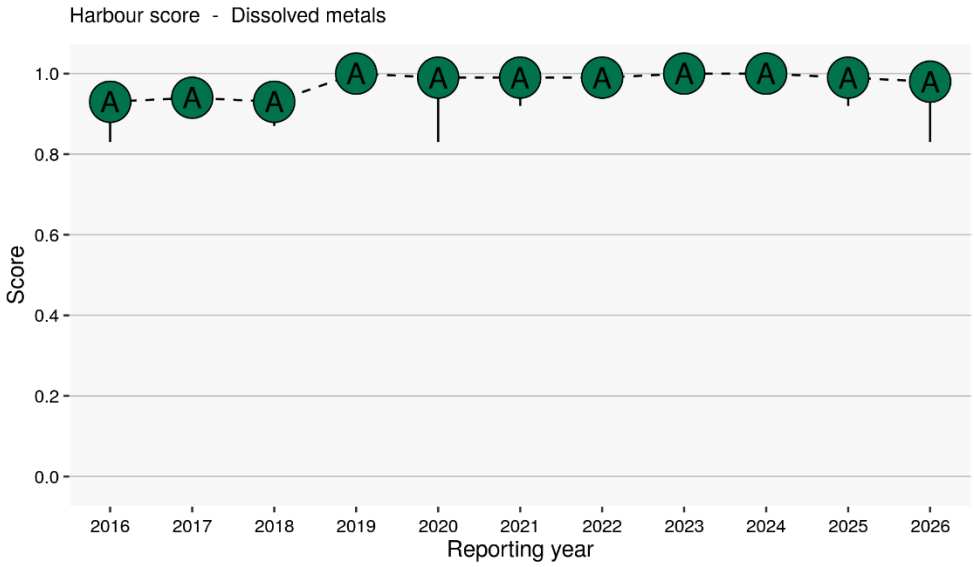

Figure 3.4 | Trends in the overall harbour score for Water quality dissolved metals sub-indicator 2016–2026 (Error bars show 95% bootstrap confidence intervals).

Sediment quality

Metals and metalloids in sediment have consistently achieved Very Good (A) grades throughout the entire monitoring period, demonstrating stable and high-performing sediment quality across the harbour (Figure 3.5). Scores have remained between approximately 0.95 and 0.98 since 2016, with only minor year-to-year variation. The consistently high results indicate that concentrations of

metals and metalloids in sediments have remained well below guideline values, with the 2026 score continuing this long-term pattern of excellent condition.

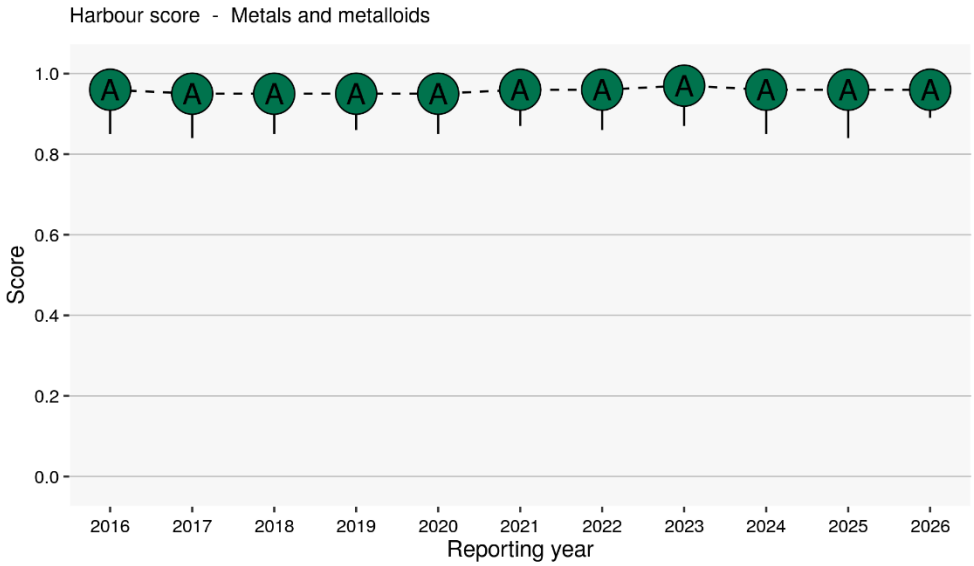

Figure 3.5 | Trends in the overall harbour score for Sediment quality indicator 2016–2026 (Error bars show 95% bootstrap confidence intervals).

3.2 Habitats

3.2.1 Seagrass

What is seagrass?

Seagrasses are the only flowering plants that can live entirely submerged in seawater. These unique, aquatic plants grow in sediment on the seafloor with erect elongate or oval leaves and a buried rhizome and root structure. Seagrasses are widely distributed along the coastlines of the world and provide a range of important functions within the marine ecosystem. There are four families of seagrass worldwide, three of which are commonly found in Gladstone Harbour. The seagrass indicators in the report card are based on five species of seagrass (Figure 3.6):

- *Zostera muelleri ssp. capricorni*
- *Halophila ovalis*
- *Halophila decipiens*
- *Halophila spinulosa*
- *Halodule univervis* (wide and narrow leaf)

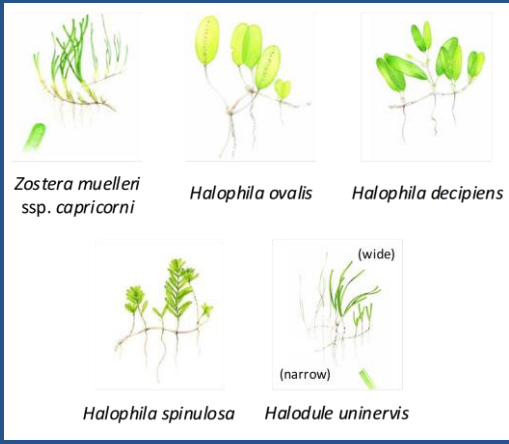

Figure 3.6 | Seagrass species

Seagrass meadows are one of the most important habitat types in Gladstone Harbour. Within the GHHP reporting area, there are 14 monitored seagrass meadows. These are located within six harbour zones: The Narrows, Western Basin, Inner Harbour, Mid Harbour, South Trees Inlet and Rodds Bay. The area and distribution of the seagrass meadows can vary annually, but at peak distribution seagrass meadows in Gladstone Harbour can cover approximately 16,000 ha (Davies et al., 2016). This area includes intertidal, shallow subtidal and deep-water habitats. Seagrasses inhabit various substrata from mud to rock. The most extensive seagrass meadows occur on soft substrata such as sand and mud. Seagrass meadows provide a range of important ecosystem functions, including sediment stabilisation, nutrient cycling and carbon sequestration. They also provide nursery areas for juvenile fishes and foraging areas for dugongs, turtles and large fish such as Barramundi.

Seagrasses are highly sensitive to reductions in available light and are susceptible to changes in a range of water quality parameters that affect light penetration. High nutrient levels from agricultural or urban run-off can cause algal blooms that shade seagrass. Increases in water turbidity from suspended sediments can reduce seagrass growth and the size and extent of seagrass meadows. This is due to a decrease in available light and the effects of sediments settling on seagrass leaves. In Gladstone Harbour, increases in turbidity may be associated with flooding, large tidal movements or dredging. At a local scale, dredging can impact seagrasses by increasing turbidity and reducing the amount of available light. While a number of factors can negatively impact seagrass growth, McCormack et al. (2013) indicated environmental conditions are key influences on seagrass meadow condition in Gladstone Harbour.

Information in the following sections is drawn from a seagrass monitoring project that commenced in 2002 (Reason et al. 2024; Smith et al., 2026), funded by the GPC. Over two decades of monitoring and research have provided insight into potential causes and trends regarding changes in the seagrass meadows of Gladstone Harbour.

3.2.2 Seagrass data collection

The Seagrass Ecology Group from the Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) at James Cook University collected data to estimate the Seagrass scores for the 2026 report card. In 2002, GPC commissioned a fine-scale survey of seagrass within the Gladstone Port Limits (Rasheed et al., 2003). This baseline survey identified large areas of seagrass within the limits of the Port of Gladstone.

The annual seagrass monitoring program started in 2004 and currently assesses 14 representative intertidal and shallow subtidal seagrass meadows in Gladstone Harbour and Rodds Bay (Figures 11.2, 11.6, 11.10, 11.16, 11.18 and 11.26). Meadows were selected to represent the range of seagrass communities within the port considered the most likely to be impacted by port facilities and future developments. Additional out-of-port reference meadows were selected at Rodds Bay. Seagrass monitoring is conducted annually in October or November around the peak of seagrass abundance.

Three sub-indicators of seagrass health were measured to calculate the seagrass scores for the Gladstone Harbour report card:

- **Biomass** – changes in average above-ground biomass within a monitoring meadow
- **Area** – changes in the total area of a monitoring meadow
- **Species composition** – changes in the relative proportions of species within a monitoring meadow

Why is the seagrass species important?

Fisheries habitat: Fish display a distinct preference for particular species of seagrass. A shift in species composition can lead to a change in the abundance and diversity of fishes.

Benthic invertebrate diversity: The abundance and diversity of benthic invertebrates differs between seagrass species. Changes in the benthic invertebrate community can result in the loss of important habitat functions and a decline in the secondary productivity of the meadow.

Coastal protection: Stiffness, biomass, density, leaf length and morphology all influence the coastal protection value of seagrass. Long-lived, slow-growing species provide the greatest protection.



Figure 3.7 | Seagrass meadow at low tide. Photo courtesy of Hannah King.

Carbon sequestration: Species composition is a known variable for carbon sequestration. Larger bodied species are generally associated with higher sedimentary organic carbon stocks.

Resistance to disturbance: Larger bodied, persistent species generally have a higher physiological resistance to disturbance, while small-bodied colonising species can recover more rapidly following disturbances.

Biomass and species composition

Above-ground biomass was estimated using visual estimates. At each site, 0.25 m^2 quadrats were placed in three randomly selected locations. Each quadrat was ranked relative to a series of photographs of quadrats for which the biomass had been previously determined. The percentage of each seagrass species within each quadrat was also recorded. After the quadrats were ranked, the observer also ranked a series of calibration photographs that represented the range of seagrass biomass observed during the survey. The field biomass ranks were then converted into estimates of above-ground biomass in grams dry weight per square metre ($gDWm^{-2}$) for each of the replicate quadrats at a site.

Area

The area of the monitored seagrass meadows was determined with ArcGIS 10.8®. For each meadow, a mapping precision estimate ranging from ≤5 m to 50–200 m was developed based on the mapping methodology (Table 3.6). Spatial data from the survey were entered into the Gladstone Harbour GIS as seagrass meadow layers.

Table 3.6 | Mapping precision and mapping methodology for seagrass meadows for the Gladstone Harbour Report Card seagrass surveys (Adapted from Smith et al., 2022).

Mapping precision	Mapping method
<5 m	Meadow boundaries mapped by GPS from helicopter Intertidal meadows completely exposed or visible at low tide Relatively high density of mapping and survey sites Recent aerial photography aided in mapping
10–20 m	Meadow boundaries determined from helicopter and boat surveys Intertidal boundaries interpreted from helicopter mapping and survey sites Recent aerial photography aided in mapping Subtidal boundaries interpreted from survey sites Moderately high density of mapping and survey sites
20–50 m	Meadow boundaries determined from helicopter and boat surveys Intertidal boundaries interpreted from helicopter mapping and survey sites Subtidal boundaries interpreted from boat survey sites Lower density of survey sites for some sections of boundary
50–200 m	Meadow boundaries determined from boat surveys Subtidal meadows interpreted from survey sites Lower density of survey sites for meadow boundary

Isolated seagrass patches
The majority of area within the meadow consists of unvegetated sediment interspersed with isolated patches of seagrass.

Aggregated seagrass patches
The meadow consists of numerous seagrass patches but still features substantial gaps of unvegetated sediment within the boundary.

Continuous seagrass cover
The majority of meadow area consists of continuous seagrass cover with a few gaps of unvegetated sediment.

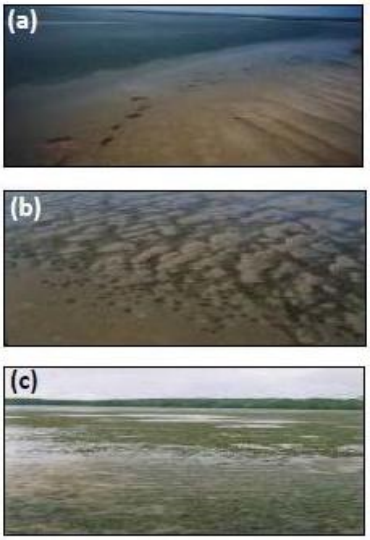

Figure 3.8 | Seagrass meadow landscape categories: (a) isolated seagrass patches, (b) aggregated seagrass patches and (c) continuous seagrass cover. Photo courtesy of JCU TropWATER.

3.2.3 Development of Seagrass indicators and scoring

Seagrass scores for the Gladstone Harbour Report Card were obtained by comparing the results for each seagrass meadow with a predetermined baseline condition for each indicator. Bryant et al. (2014) found that the most appropriate baseline was a fixed 10-year (2002–12) average calculated from previous seagrass surveys.

To estimate seagrass grades, threshold levels for each grade (A–E) were developed based on:

- the historical variability within each meadow
- expert knowledge of meadow types
- tests at a range of thresholds to determine which best fits the historical data

Threshold ranges were developed for the meadow types for the sub-indicator's biomass, area and species composition (Table 3.7). Scores for each sub-indicator were based on these thresholds and a score between 0.00 and 1.00 was calculated to fit the Gladstone Harbour Report Card grade range.

Between 2015 and 2017, the overall score for each monitoring meadow was defined as the lowest score received for each of the three indicators. The lowest score, rather than the mean of the three indicator scores, was applied because a poor score for any one of the three indicators described a seagrass meadow in poor condition. A review in 2018 of how meadow scores were calculated led to a change in this method. The new method still defines overall meadow condition as the lowest indicator score when this score is either meadow area or biomass; however, where species composition is the lowest score, the overall meadow score is 50% of the species composition score and 50% of the next lowest score (area or biomass). This change was applied to correct an anomaly noted in the 2017 report card where the Inner Harbour received a score of zero owing to a species composition score of zero despite having very good biomass and good area grades. The change acknowledges that the species composition is an important characteristic of a seagrass meadow in terms of defining meadow stability, resilience, and ecosystem services, but is not as fundamental as having seagrass present.

The zone score is the average of the overall meadow scores within that zone, and the overall harbour score is the mean of the zone scores.

Note, the 2026 Gladstone Harbour Report Card scores may differ slightly to those reported by Smith et al. (2026) due to bootstrapping used to calculate Gladstone Harbour Report Card scores. The bootstrapping method resamples the original data many times to yield multiple means which are used to develop a series of distributions for measures, sub-indicators, indicators, and indicator groups. By aggregating distributions (rather than individual means), the rich distributional properties could be preserved, sample bias could be avoided and means (the report card score) and variances could be calculated for reporting.

Table 3.7 | Threshold values between grades A to E varied for the seagrass meadow types for each of the three seagrass sub-indicators (biomass, area and species composition). Each grade was determined by the percentage difference from a baseline of the 10-year mean (Adapted from Smith et al., 2022).

Seagrass condition indicators/ Meadow class		**Seagrass grade**				
		Very Good (A)	Good (C)	Satisfactory (C)	Poor (D)	Very Poor (E)
Biomass	Stable	>20% above	20% above–20% below	20–50% below	50–80% below	>80% below
	Variable	>40% above	40% above–40% below	40–70% below	70–90% below	>90% below
Area	Highly stable	>5% above	5% above–10% below	10–20% below	20–40% below	>40% below
	Stable	>10% above	10% above–10% below	10–30% below	30–50% below	>50% below
	Variable	>20% above	20% above–20% below	20–50% below	50–80% below	>80% below
	Highly variable	>40% above	40% above–40% below	40–70% below	70–90% below	>90% below
Species composition	Stable and variable; Single species dominated	>0% above	0–20% below	20–50% below	50–80% below	>80% below
	Stable; Mixed species	>20% above	20% above–20% below	20–50% below	50–80% below	>80% below
	Variable; Mixed species	>20% above	20% above–40% below	40–70% below	70–90% below	>90% below

3.2.4 Seagrass results

Seagrass condition across Gladstone Harbour retained a Good (B) grade during the 2026 reporting year (based on October 2025 monitoring), with the overall harbour score of 0.78 (Table 3.8). This represents a slight decrease in score from 2025 (0.81) but remains higher than the 2024 score (0.68), continuing the recovery observed over recent years.

At the meadow scale, 12 of the 14 monitored meadows were graded as Good (B) or Very Good (A), with seven meadows achieving Very Good (A) grades. Seagrass biomass and area were among the highest recorded since monitoring commenced, with record biomass observed in Western Basin Meadows 5 and 52–27, as well as all monitored meadows in Rodds Bay.

Table 3.8 | Seagrass sub-indicator, overall meadow and zone scores used in the 2026 Gladstone Harbour Report Card.

Zone	Meadow	Biomass	Area	Species comp.	Overall meadow	2026	*2025*	*2024*
1. The Narrows	21	1.00	0.92	0.98	0.92	0.92	*0.99*	*0.89*
3. Western Basin	4	1.00	1.00	0.79	0.93	0.83	*0.78*	*0.70*
	5	1.00	0.96	0.88	0.92			
	6	0.92	0.90	0.55	0.72			
	7	0.81	0.77	1.00	0.77			
	8	0.97	0.81	0.66	0.73			
	52–57*	1.00	0.88	1.00	0.88			
5. Inner Harbour	58	0.87	0.81	0.43	0.62	0.62	*0.62*	*0.43*
8. Mid Harbour	43	0.50	0.81	0.84	0.50	0.60	*0.70*	*0.49*
	48	0.70	0.81	0.81	0.70			
9. South Trees Inlet	60	0.83	1.00	1.00	0.83	0.83	*0.88*	*0.81*
13. Rodds Bay	94	1.00	0.86	1.00	0.86	0.91	*0.89*	*0.74*
	96	1.00	1.00	0.99	1.00			
	104	1.00	0.86	1.00	0.86			
Harbour score						0.78	*0.81*	*0.68*

*Meadow 52-57 consists of a number of small meadows surrounding the Passage Islands in the Western Basin Zone. These meadows are grouped for reporting purposes.

Zone 1 – The Narrows

The Narrows features a single monitored meadow at Black Swan Island, an intertidal area characterised by variable biomass. Meadow condition has improved since monitoring began in 2015 and has retained a Very Good (A) grade since 2022. This five-year period of consistently high scores (0.89–0.99) is the longest recorded among all monitored meadows.

Zone 3 – Western Basin

The Western Basin has six monitored seagrass meadows: five intertidal and one subtidal (Meadow 7). Seagrass condition in the Western Basin remained strong in 206, retaining a Good (B) grade and overall zone score of 0.83, an increase from 0.78 in 2025. Three meadows (4, 5 and 52–57) were assessed as Very Good (A), while the remaining meadows (6,7 and 8) were graded Good (B). Biomass remained high across the zone, notably Meadows 4, 5 and 52-57 receiving the maximum score of 1.00. Area scores were largely consistent with 2025, although Meadow 8 declined slightly from 0.87 to 0.81. Species composition improved in Meadows 5, 6 and 8, with Meadow 8 showing the largest increase, improving from 0.46 in 2025 to 0.66 in 2026. In contrast,

species composition at Meadow 4 declined slightly from 0.86 to 0.79, although it retained a Good (B) grade.

Zone 5 – Inner Harbour

The Inner Harbour contains a single monitored seagrass meadow (Meadow 58) located in the in south-east corner of the zone near South Trees Inlet. In 2026, Meadow 58 retained in a Satisfactory (C) grade. An increase in biomass score from 0.75 in 2025 to 0.87 in 2026, was offset by slight declines in area (0.84 to 0.81) and species composition (0.49 to 0.43). As a result, overall meadow condition remained stable between years.

Zone 8 – Mid Harbour

Mid Harbour has two monitored meadows adjacent to the south-east corner of Curtis Island. Meadow 43, known locally as Pelican Banks, is the largest (baseline = 632 ha) and most productive (baseline = 19 $gDWm^{-2}$) seagrass meadow assessed for the report card. It is also the only meadow where all three indicators are classed as stable or highly stable. Pelican Banks is an intertidal meadow while Meadow 48 is a subtidal meadow neighbouring the eastern side of Quoin Island.

Mid Harbour declined from a Good (B) grade in 2025 to a Satisfactory (C) grade in 2026, driven primarily by reduced seagrass biomass at Pelican Banks (Meadow 43). Despite the decline in biomass, meadow area and species composition remained in good condition, indicating that the meadow continues to support a representative seagrass community. In contrast to Meadow 43, Meadow 48 retained a healthy extent and representative seagrass community retaining a Good (B) grade for the meadow.

Zone 9 – South Trees Inlet

This zone has one monitored meadow which sits off the northern tip of South Trees Island. Meadow 60 is an intertidal meadow and the second smallest of the monitored meadows. The meadow remained in a similar condition to the previous year, with nearly identical scores for area and species composition. A slight decline for biomass resulted in a lower meadow score and decline in overall grade to Good (B) from 2025.

Zone 13 – Rodds Bay

Rodds Bay has three intertidal seagrass monitoring meadows: Meadows 94, 96, and 104. Rodds Bay recorded a Very Good (A) grade, with a zone score of 0.91, making it one of the highest-performing seagrass monitoring zones in Gladstone Harbour in 2026. The zone improved slightly from a score of 0.89 in 2025 and has shown a strong recovery from 0.74 in 2024. All three monitored meadows were assessed in very good condition, supported by very high biomass, meadow area and species composition scores.

A key finding of the monitoring program was that record high biomass was observed across all three Rodds Bay meadows, with seagrass biomass among the highest recorded since monitoring commenced in 2002. These results reflect favourable growing conditions during 2025, including low rainfall, reduced river flows and improved water clarity, which supported strong seagrass growth throughout the region.

3.2.5 Seagrass discussion

Seagrass across Gladstone Harbour remained in good condition in 2026, continuing a positive trajectory observed over recent years. Overall harbour scores were supported by strong biomass, meadow area and species composition across most monitored meadows, with 12 of the 14 meadows assessed with Good (B) or Very Good (A) grades. Seagrass biomass and meadow extent also remained among the highest levels recorded since monitoring commenced, indicating that seagrass communities across the harbour continue to demonstrate resilience and recovery following historical declines.

Long-term monitoring has consistently shown a strong relationship between seagrass condition and regional rainfall and river flow (McCormack et al., 2013). During the report card monitoring period, below-average rainfall and reduced freshwater inflows resulted in favourable water quality conditions, including improved water clarity and increased light availability. These conditions are known to promote seagrass growth and are likely to have contributed to the high biomass and meadow extent observed across many areas of the harbour. Similar patterns have been reported across Queensland's east coast, where seagrass meadows have generally recovered since the widespread losses recorded during 2009 and 2010, although recovery rates have varied among regions depending on local environmental conditions and disturbance history (Smith et al., 2024).

Despite the positive results across Gladstone Harbour, some localised variation in condition was observed. Mid Harbour declined from a Good (B) grade in 2025 to a Satisfactory (C) grade in 2026, largely due to reduced biomass at Pelican Banks (Meadow 43). While meadow area and species composition remained in good condition, lower biomass reduced the overall meadow score and contributed to the decline in the Mid Harbour zone score. This pattern suggests that factors affecting seagrass biomass, rather than meadow extent or species composition, were primarily responsible for the reduced condition observed at this site.

Long-term studies have shown that herbivory by green turtles and dugongs can influence seagrass meadow condition and recovery dynamics (Rasheed et al., 2017; Christianen et al., 2014). Experimental research by Scott et al. (2021) identified Pelican Banks as one of the most heavily grazed meadows in the Port Curtis region, with greater reductions in seagrass biomass and canopy height than observed at other monitored meadows. Continued aquatic grazing pressure may therefore contribute to the lower biomass observed at Pelican Banks, potentially slowing recovery despite otherwise favourable environmental conditions.

Overall, the 2026 results indicate that seagrass meadows across Gladstone Harbour remain healthy and resilient. Favourable environmental conditions have supported strong seagrass growth across much of the harbour, although localised pressures such as herbivory and site-specific environmental factors continue to influence meadow condition. Ongoing monitoring remains important for understanding these dynamics and assessing the resilience of seagrass ecosystems.

3.2.6 Seagrass trends

Seagrass condition in Gladstone Harbour has improved markedly over the past decade (Figure 3.9 and Table 3.9). Overall harbour scores remained in the Poor (D) grade range from 2015 to 2018 before improving to a Satisfactory (C) grade in 2019 and a Good (B) grade in 2020. Although scores fluctuated in subsequent years, seagrass has consistently remained in the Good (B) grade range since 2024. The 2026 score of 0.78 represents a slight decline from the 2025 peak of 0.81 but remains among the highest recorded, indicating that seagrass meadows across the harbour continue to be in strong condition.

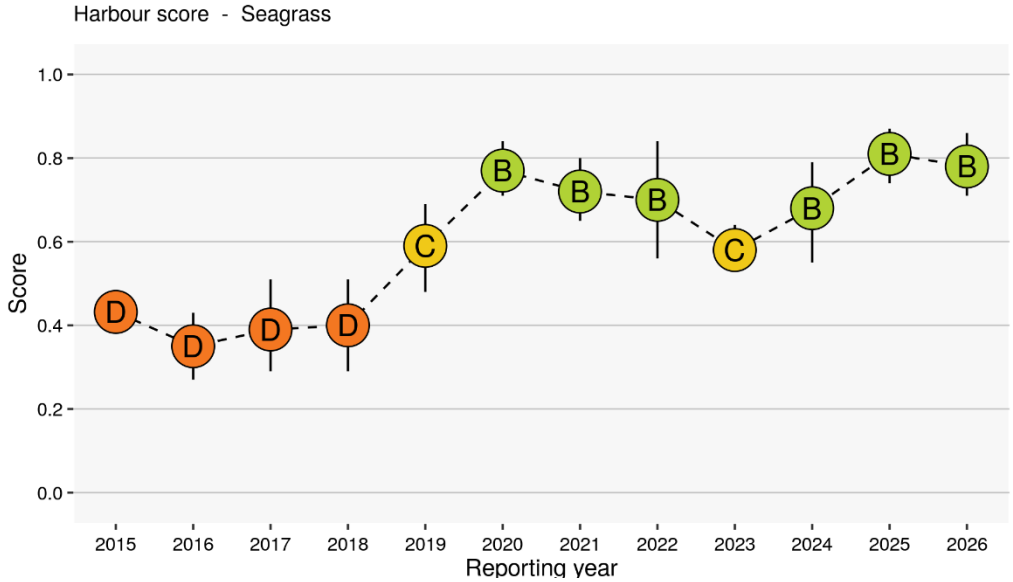

Figure 3.9 | Trends in the overall harbour score for Seagrass 2015–26 (Error bars show 95% bootstrap confidence intervals).

Table 3.9 | Grades for individual seagrass monitoring meadows from annual surveys, 2002–25. Note, report card and monitoring years differ (e.g. 2026 report Card = Nov. 2023 monitoring).

Zone	Meadow	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018*	2019	2020	2021	2022	2023	2024	2025
1. The Narrows	21								A	B	B	C	E	D	D	C	D	B	B	B	A	A	A	A	A
3. Western Basin	4	B		C	D	B	A	B	A	E	D	B	D	D	C	B	D	C	A	A	A	B	A	A	A
	5	C		D	C	B	B	A	C	D	D	C	E	D	D	C	C	C	A	B	A	B	B	A	A
	6	B		D	C	B	A	B	A	E	D	D	D	B	B	B	D	C	B	B	B	B	C	B	B
	7	B		B	E	A	D	B	D	E	E	E	D	B	B	D	E	A	B	C	C	C	C	B	B
	8	A		D	E	B	B	B	B	C	E	D	E	D	D	E	D	D	B	C	B	C	C	B	B
	52-57								C	E	E	B	B	C	D	B	B	A	B	B	A	A	B	A	A
5. Inner Harbour	58	B		D	B	D	B	B	B	E	D	C	E	D	D	D	E	E	B	C	D	E	D	C	C
8. Mid Harbour	43	B		B	B	C	C	A	B	B	C	C	C	C	D	E	D	D	D	D	C	D	D	B	C
	48	B		C	B	B	A	B	E	D	D	D	C	D	D	C	C	C	C	C	B	B	D	B	B
9. South Trees	60	A		E	E	B	A	A	C	E	E	C	E	C	D	B	A	A	A	A	A	B	B	A	B
13. Rodds Bay	94	A		D	A	B	A	A	E	E	E	E	E	D	E	E	E	C	A	B	E	D	B	A	A
	96	B		D	C	B	A	A	B	D	E	D	E	D	D	D	E	B	A	B	B	D	B	A	A
	104	B		D	B	B	B	A	C	E	E	E	E	C	D	E	E	D	A	C	C	D	B	B	A

*Note: 2018 scoring calculation methods changed to acknowledge that species composition is an important characteristic of a seagrass meadow, but not as fundamental as seagrass presence

3.2.7 Coral

Coral communities are iconic components of marine ecosystems in Australia. In addition to their high biodiversity, coral reefs provide spawning, nursery and feeding areas for fish and a variety of other animals. These include sea turtles, crustaceans (such as prawns and crabs) and a large range of benthic organisms such as echinoderms (e.g. sea stars, sea cucumbers, sea urchins), molluscs, sponges and worms. Reefs also provide important ecosystem services such as nutrient recycling, and carbon and nitrogen fixation. In addition to their ecological value, coral reefs have considerable socio-economic importance.

Reefs within the Gladstone Harbour monitoring zones include fringing, platform, headland and rubble fields with hard and soft corals (BMT WBM, 2013). Within the Gladstone Harbour area, reefs have been recorded in the intertidal zones that have suitable substrata and sufficient light penetration around Turtle, Quoin, Rat, Facing and Curtis islands and at Seal Rocks. Coral communities have also been recorded within deeper channels (>5 m) in The Narrows, around Passage Island and the North Passage. Regions of hard and soft coral also occur along the northern edge of Hummock Hill Island and limited coral reef development has also been identified in Rodds Bay (BMT WBM, 2013; DHI, 2013).

Threats to coral reefs include natural and anthropogenic pressures that can operate at global (e.g. climate change, El Niño Southern Oscillation), regional or local scales. These pressures include negative effects from large-scale flooding, sedimentation, urban pollution and agricultural run-off. Coral reef communities within Gladstone Harbour can be exposed to freshwater run-off, elevated turbidity and nutrient levels, and can be vulnerable to the negative impacts of sediments and increases in macroalgal cover (DHI, 2013).

Four sub-indicators of coral health were measured to calculate the coral score for the 2026 Gladstone Harbour Report Card:

1. Coral cover: the combined cover of hard and soft corals observed at the monitored reefs
2. Macroalgal cover: the cover of macroalgae observed at the monitored reefs
3. Juvenile coral density: the density of juvenile corals observed at the monitored reefs
4. Change in hard coral cover: averaged over a three-year period to give the rate at which hard coral cover increases or decreases.

3.2.8 Coral data collection

Establishment of long-term monitoring sites

Coral surveys in July 2015 identified suitable sites for the long-term monitoring program. Prior to starting the surveys, existing reports on coral community locations were used to identify potential sites for long-term coral monitoring (BMT WBM, 2013; DHI, 2013) in the Inner Harbour, Mid Harbour and Outer Harbour zones. The review identified three islands within the Inner Harbour as possible sites for coral monitoring: Quoin, Turtle and Diamantina. However, surveys for areas of hard substrate and subsequent spot checks of the benthic communities were unable to locate suitable monitoring sites. The search for potential Inner Harbour survey sites was hampered by low underwater visibility on both rising and falling tides.

Four permanently marked survey sites (transects) were established in the Mid Harbour at Rat Island, Farmers Reef, Facing Island and Manning Reef and two permanent sites were established in the Outer Harbour at Seal Rocks North and Seal Rocks South (Figures 3.10, 11.16 and 11.22).

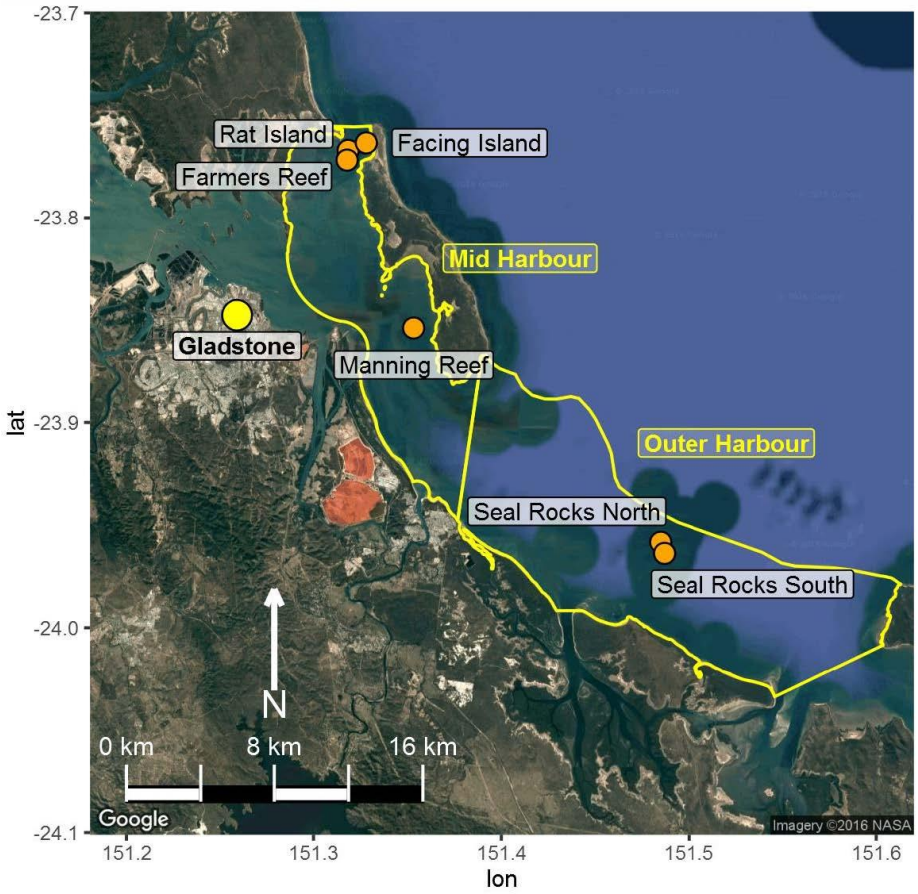

Figure 3.10 | Gladstone Harbour Coral monitoring sites (Thompson et al., 2026).

Coral monitoring

Coral monitoring was conducted in May 2026 and included the following three methodologies:

Photo point intercept transects
The methodology outlined below closely follows that outlined in the AIMS Long-term Monitoring Program (Jonker et al., 2008). At each 20 m transect, digital photographs were taken at 50 cm intervals. Estimates of the cover of benthic components, including coral and macroalgae, were made from five fixed points overlayed on each digital image. Most hard and soft corals were identified to genus.

Juvenile corals
Juvenile coral colonies, up to 5 cm in diameter were counted within a 34 cm band along each permanently marked transect. Each colony was identified to genus and assigned to a size class of 0–2 cm or 2–5 cm. The number of juvenile colonies observed along a fixed transect area will be affected by the availability of suitable substrata for settlement. To allow comparisons between reefs and over time, the numbers of recruits along each fixed transect were converted to densities per area available for settlement.

Disturbances
Incidences of coral disease, coral bleaching, coral predation by crown-of-thorns starfish, overgrowth by sponges, and smothering by sediments were counted along a two-metre belt centred on the transect tape. These data are not used in the calculation of report card scores. In the long term, however, they may be valuable for explaining changes in coral condition.

3.2.9 Development of coral sub-indicators and scoring

Each of the four coral sub-indicators was scored against a baseline based on expert opinion and data from the Marine Monitoring Program (MMP) for inshore reefs. The baseline for each of the four sub-indicators represented the threshold between report card grades of satisfactory condition (C) and poor condition (D). The highest possible score of 1.00 was set to represent coral reefs in as good condition as could be expected in the local environment (Table 3.10; Figure 3.11). The lowest score of 0.00 was set to represent the worst condition that could be expected in the local environment (Table 3.10; Figure 3.11). Although it is possible for the observed results to be outside those limits, the scores were capped at 0.00 and 1.00 to allow scaling to the GHHP range of grades.

Combined cover of hard and soft coral

Healthy coral communities have sufficient recruitment and growth of colonies to replace losses resulting from disturbances and environmental limitations. High coral cover suggests that a large brood-stock is available, which increases the potential of other reefs in the vicinity to recover from disturbance. High coral cover also contributes to the structural complexity of a reef and increases its biodiversity by providing habitat for fishes and other marine organisms. Both hard and soft coral cover were included in the assessment.

A detailed description of the development of the critical values and thresholds for coral cover are presented in Thompson et al. (2015). The values and thresholds used for the combined coral cover are based on two prior assessments of coral cover on nearshore reefs. A broad-scale survey of nearshore reefs between Cape Tribulation and the Keppel Islands conducted in 2004 using the same sampling methods as the Gladstone Harbour surveys returned a mean hard coral cover of 33% and 5% cover for soft corals (Sweatman et al., 2007). This 38% mean was observed after severe loss of corals owing to thermal bleaching in 1998 and 2002 and is considered too low for a threshold that would indicate a good condition (Thompson et al., 2015). A summary of coral surveys from over 100 sites between Cape Flattery and the Keppel Islands in 1996 prior to the bleaching events found a mean coral cover of hard corals of approximately 48% when the results were corrected to be consistent with MMP methods (Thompson et al., 2015). Allowing for some soft coral cover and rounding to an even percentage a 50% threshold for coral cover was proposed for the MMP and adopted for use in the Gladstone Harbour report card. Correcting for the differences in the grading schemes between the Reef Report Card and the Gladstone Harbour Report Card a 40% threshold is applied (Table 3.10). This figure is consistent with surveys conducted in Gladstone Harbour (Mid Harbour) prior to 2009 where a mean hard coral cover of 39% was reported (BMT WBM, 2013). Although the BMT WBM (2013) report did not provide a mean estimate for soft coral cover, the report indicates soft coral cover in the middle harbour ranged between ~4% and 40%.

It should be noted that while the thresholds and bounds were originally selected to be consistent with MMP reporting, subsequent changes to the thresholds and bounds for coral cover in the MMP (Thompson et al., 2016) mean that MMP thresholds are no longer consistent with the Gladstone Harbour Report Card.

Macroalgal cover

Macroalgae can suppress coral by increased competition for space and by changing the micro-environment and inhibiting coral colonisation and growth (Foster et al., 2008; Cheal et al., 2010). Once established, macroalgae occupy space that might otherwise be available for coral growth and recruitment. For this sub-indicator, macroalgae belonging to the Rhodophyta (red algae), Phaeophyta (brown algae) and Chlorophyta (green algae) were assessed.

Critical values for macroalgal cover were developed through the MMP and fitted to the Gladstone Harbour Report Card grading scheme (Figure 2.1). A baseline of 14% macroalgal cover was set at the C/D threshold (the point where the grade changes from passing to failing) for coral communities in Gladstone Harbour (Table 3.10).

Owing to changes in the calculation of macroalgae scores in the MMP, including the use of reef-specific water quality conditions (Thompson et al., 2016), a direct comparison of macroalgae scores between the MMP and the Gladstone Harbour Report Card is not possible.

Juvenile coral density

Recovery of coral reefs from disturbances such as flooding, cyclones, thermal bleaching or outbreaks of crown-of-thorns starfish is dependent on the recruitment of new coral colonies and regeneration of existing colonies. The number of juvenile colonies at a reef can be negatively affected by poor water quality particularly where there is elevated concentrations of nutrients and agrichemicals and high turbidity (van Dam et al., 2011; Erftemeijer et al., 2012). High rates of sediment deposition (Rogers, 1990) and a high cover of macroalgae (Foster et al., 2008; Mumby and Steneck, 2008) will also negatively impact the number of juvenile colonies observed. Hence juvenile coral density can provide an indication of a reef's potential for recovery from disturbance given the current conditions.

Prior to 2018, coral in three size classes (0–2 cm, >2–5 cm and >5–10 cm) were identified to the genus level and recorded. In 2018, the >5–10 cm class was discontinued to realign the methodology with that used in the MMP (Thompson et al., 2016). This method was adopted by the MMP because limiting observations to the 0–5 cm range more accurately focuses on juvenile rather than fragmented colonies or small colonies of slow growing corals, which may be mistaken for juvenile colonies and do not reflect recent recruitment and survivorship dynamics.

Thresholds for juvenile coral density were set based on data on the densities of juvenile colonies recorded over four years of the MMP (2005–09). That monitoring determined the mean density of juvenile corals for inshore reefs at sites 2 m below lowest astronomical tide to be about 7.7 juvenile corals per m^2 of available substrate. For this study, the limits were set at 0 and 13 juvenile colonies per m^2 respectively (Table 3.10).

Change in hard coral cover

While low coral cover may occur following acute disturbance such as large floods, it does not necessarily give a good indication of the coral community's ability to recover. This is assessed by measuring the rate at which hard coral cover increases and provides a direct measure of recovery potential. This sub-indicator captures the coral growth performance per reef by comparing observed rate of change (where there is no acute disturbance) to the rate of change observed in the time series of coral cover from 47 near-shore reefs monitored by the AIMS Long-Term Monitoring Program and the MMP from 1987–2007.

The model projections of future coral cover on Great Barrier Reef inshore reefs over the period 1987–02 indicated a long-term decline in coral cover (Thompson and Dolman, 2010). For this reason, the positive score of 1 was reserved for those reefs at which the observed rate of change in cover exceeded the twice the upper 95% confidence interval of the change predicted. Observations falling within the upper and lower confidence intervals of the change in predicted cover were scored as neutral (sub-indicator score 0.5) and those below twice the lower confidence interval of the predicted change received a sub-indicator score of 0. The rate of change is averaged over three years of observations including the most recent. Therefore, it was not possible to have this metric in the Gladstone Harbour Report Card until the third year of surveys in 2017. Years in which disturbance events occurred at particular reefs were not included as there is no logical expectation for an increase in cover in such situations.

While the threshold has been adjusted to suit the grading scheme used in the Gladstone Harbour Report Card (Gladstone Harbour Threshold = 0.5, MMP threshold = 0.4), the thresholds and bounds are broadly consistent with those used in the MMP (see Thompson et al., 2016).

Table 3.10 | Coral sub-indicator thresholds for the Gladstone Harbour Report Cards.

Sub-Indicator	Baseline^	Upper bound (score = 1.00)	Lower bound (score = 0.00)
Combined cover of hard and soft corals	40%	90%†	0%
Macroalgal cover	14%	5%	20%
Juvenile coral density	4.6 m^{-2}	13 m^{-2}	0 m^{-2}
Change in hard coral cover	Lower 95% confidence interval	Twice the upper 95% confidence interval	Twice the lower 95% confidence interval

^aligned with the report card C/D threshold of 0.50. †Reduced from 100% as coral cover rarely attains 100% coverage due to areas of colonisable substrate and variable population dynamics.

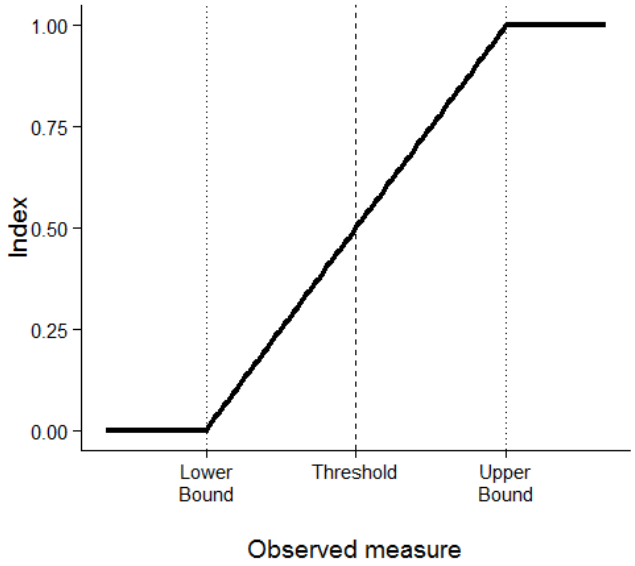

Figure 3.11 | Generic scoring of the coral sub-indicators based on the threshold and bounds outlined in Table 3.10.

Aggregation of sub-indicator scores

Bootstrapping was used to aggregate individual scores for each sub-indicator within a zone to produce the zone score. This involved constructing a bootstrap distribution of 10,000 samples for each sub-indicator in each zone. The mean of those distributions represented the zone score for each sub-indicator. Aggregating the sub-indicator distribution from each zone (sub-indicator score) generated the harbour level scores, and the overall harbour indicator score was calculated as the mean of the harbour sub-indicator scores.

3.2.10 Coral results

Coral received an overall Very Poor (E) grade and a very low score of 0.14 (Table 3.11). This low score reflects the low cover of living coral, high macroalgal cover, low abundance of juvenile corals and minimal change in hard coral cover across most surveyed reefs. Macroalgal cover improved in Mid Harbor from 0.19 in 2025 to 0.50 in 2026 and moderate improvements in change in hard coral cover from 0.18 to 0.30, however overall zone scores were minor between 2025 and 2026 for the remaining sub-indicators within ±0.06 of the previous year's scores.

Table 3.11 | Coral sub-indicator and zone scores used in the 2026 Gladstone Harbour Report Card.

Zone	Coral cover	Macroalgal cover	Juvenile density	Change in hard coral cover	2026	*2025*	*2024*
8. Mid Harbour	0.08	0.50	0.10	0.30	0.24	*0.13*	*0.17*
11. Outer Harbour	0.07	0.00	0.06	0.06	0.03	*0.04*	*0.12*
Harbour score*	0.07	0.25	0.08	0.15	0.14	*0.09*	*0.14*

*Overall harbour scores an average of all six reef rather than average of zone scores.

Coral cover remained low throughout the harbour, with a harbour-wide average of 5.8%, well below the 40% threshold used to indicate satisfactory condition (Table 3.12). Small increases in coral cover were observed at several reefs during 2026, particularly at Rat Island (11.6%) and Facing Island (8.3%), while Manning Reef remained extremely low at just 0.5%. In the Outer Harbour, Seal Rocks South maintained moderate coral cover (8.3%), whereas Seal Rocks North remained very low (2.2%). Coral cover scores therefore retained Very Poor (E) grades across the harbour.

Macroalgae continued to be a major pressure on reef recovery. Harbour-wide macroalgae cover remained high, although reductions at several Mid Harbour reefs improved the macroalgae sub-indicator score grade from Very Poor (E) to Poor (D) (Table 3.11). Rat Island (3.1%) and Farmers Reef (1.7%) recorded substantial declines in macroalgae and achieved very high site-level scores (Table 3.12). In contrast, Manning Reef (67.7%) and both Seal Rocks reefs (44.9 and 52.1%) continued to support extensive macroalgal communities that may be limiting coral recruitment and growth.



Figure 3.12 | Large Dispsataea coral at Farmers Reef. The upper portion is bleached in response to high summer seawater temperatures. Photo courtesy of AIMS.

Juvenile coral density remained one of the weakest indicators, scoring very low across the harbour (Table 3.12). Average juvenile density declined further to 0.8 corals m^{-2}, well below the threshold associated with successful reef recovery. Recruitment of fast-growing Acropora corals remained rare and juvenile densities across most reefs were lower than those observed at the start of monitoring. These results suggest that coral replenishment processes remain severely constrained.

The coral change indicator also remained graded Very Poor (E), indicating that coral communities are not recovering at the rates expected under favourable conditions (Table 3.11). The Mid Harbour showed some improvement, with Facing Island achieving a satisfactory score and Rat Island and Farmers Reef improving to a Poor (D) grade. However, both Outer Harbour reefs (Seal Rocks North and Seal Rocks South) received scores of zero, resulting in a very poor Outer Harbour assessment and keeping the harbour-wide score low.

Table 3.12 | Individual Coral sub-indicator values and scores by reef.

Reef	Coral cover		Macroalgal cover		Juvenile density		Change in hard coral cover	
	Value (%)	score	Value (%)	score	Value (m^2)	score	Value (%)	score
8. Mid Harbour								
Facing Island	8.3	0.52	30.7	0.00	0.3	0.04	4.4	0.10
Farmers Reef	4.9	0.33	1.7	1.00	1.6	0.17	2.5	0.06
Manning Reef	0.5	0.04	67.7	0.00	0.5	0.05	0.00	0.01
Rat Island	11.6	0.30	3.1	1.00	1.2	0.13	2.7	0.14
11. Outer Harbour								
Seal Rocks North	2.2	0.03	52.1	0.00	0.70	0.08	-0.30	0.03
Seal Rocks South	8.3	0.10	44.9	0.00	0.50	0.05	-0.60	0.10

3.2.11 Coral discussion

Initial Coral monitoring in the Gladstone Harbour Report Card in 2015 highlighted very low coral cover, reflecting the severe impact of the 2013 floods (Thompson et al. 2015). Reduced salinity levels from freshwater run-off in flood plumes are a known cause of coral mortality. In January 2013, heavy rainfall from TC Oswald caused major flooding in the Boyne and Calliope rivers, temporarily lowering salinity levels within Gladstone Harbour. Data from the Mid Harbour showed that salinity levels stayed below 20 PSU for about three days (27–29 January 2013), with a minimum of 5 PSU recorded on 28 January (Vision Environment Queensland 2013a, b). These sustained low salinities likely caused coral mortality in the harbour. Research by Berkelmans et al. (2012) established a salinity threshold of 22 PSU for *Acropora* corals, such as staghorn and elkhorn, over three days; exceeding this threshold can result in coral death. Since the severe flooding in 2013, recovery of coral communities in Gladstone Harbour has been limited.

Although coral cover has remained low since monitoring began in 2015, the recovery potential of these reefs is the key indicator of their overall condition. The scores for macroalgal cover, juvenile density, and changes in hard coral cover are specifically designed to assess this recovery process. Unfortunately, the consistently poor to very poor grades across these three sub-indicators underscore the limited recovery potential of corals in Gladstone Harbour.

The results strongly suggest a continued shift from coral to macroalgal dominance within Gladstone Harbour. The persistently poor to very poor grades across sub-indicators support studies that demonstrate density-dependent feedback mechanisms, which favour macroalgal dominance in conditions that promote its proliferation (Mumby et al., 2007; Mumby et al., 2013). The consistently high macroalgal cover may be hindering coral recruitment by occupying space needed for juvenile settlement. Data from the MMP reveal a general pattern of high macroalgal cover coupled with low juvenile coral densities on several reefs. The poor to very poor grades for changes in hard coral cover are also likely influenced by coral-macroalgae interactions. Macroalgae genera such as *Sargassum*, *Asparagopsis*, and particularly *Lobophora* and *Dictyota* have direct negative impacts on living corals (Lirman, 2001; Vega Thurber et al., 2012; Morrow et al., 2017). Additionally, the widespread presence of the bio-eroding sponge *Cliona orientalis* remains a contributor to coral mortality within the harbour (Table 3.13). Coral bleaching due to high water temperatures in early 2020 has likely further contributed to the current condition. Ongoing monitoring since 2015 shows a clear lack of recovery following the severe coral loss noted that year.

In the broader context of inshore reefs on the Great Barrier Reef, coral communities in Gladstone Harbour perform poorly compared to other reefs monitored by the MMP (Thompson et al. 2024). Unsurprisingly, the Gladstone Harbour reefs are regionally most similar to those in the Fitzroy Region, particularly Pelican Island. Located near the mouth of the Fitzroy River, Pelican Island was severely impacted by flooding in 2011. Like the reefs in Gladstone Harbour, coral recovery at Pelican Island has been minimal, with high cover of red and brown macroalgae persisting through

2021. Reefs monitored by GHHP also closely resemble those at Daydream and Double Cone islands in the Whitsundays region, which were severely impacted by tropical cyclone (TC) Debbie in 2017. The coral communities at Pelican Island, Daydream Island, Double Cone Island, and Gladstone Harbour share common characteristics, including low coral cover, high macroalgae cover, or a combination of both.

Table 3.13 | Causes of coral mortality at time of survey in 2026. Survey area of 200 m^2 at each reef. Data from 2020–23 included for comparison. Bio-eroding sponge is primarily *Cliona orientalis*.

Reef	Damage	Genus	Colonies affected						
			2020	2021	2022	2023	2024	2025	2026
Facing Island	Bio-eroding sponge	*Porites*	22	8	10	17	14	13	24
		Turbinaria	-	1	-	-	-	-	-
	Atramentous necrosis	*Psammocora*	-	-	-	1	1	-	-
	Bleaching		0–5%	-	-	-	1–5%	-	-
Farmers Reef	Atramentous necrosis	*Cyphastrea*	-	2	-	-	1	1	-
	Bio-eroding sponge	*Cyphastrea*	7	4	7	8	-	6	10
		Porites	-	-	1	-	1	1	2
	Bleaching		0–1%	-	-	-	1–5%	-	-
	Unknown	*Porites*	-	-	1	-	-	-	-
Manning Reef	Bio-eroding sponge	*Psammocora*	-	-	-	-	1	1	-
	Bleaching		-	-	-	-	-	<1%	-
	Physical		-	-	-	-	-	<1%	-
	White syndrome	*Duncanopsammia*	-	-	-	-	-	1	-
	Unknown		-	-	-	-	-	-	1
Rat Island	Atramentous necrosis	*Cyphastrea*	-	1	7	1	-	-	-
	Bio-eroding sponge	*Cyphastrea*	8	9	5	10	3	5	7
		Plesiastrea	1	-	-	-	-	-	-
		Porites	-	-	1	-	-	-	-
		Turbinaria	4	3	2	41	3	1	-
		Favites	1	1	-	-	1	1	1
	Black band disease	*Turbinaria*	1	-	-	-	-	-	-
	Bleaching		0–10%	-	-	-	-	-	-
Seal Rocks North	Bio-eroding sponge	*Favites*	-	-	-	1	-	-	-
		Goniopora	-	-	-	1	-	-	-
		Turbinaria	-	-	-	3	-	-	-
	Bleaching		1–50%	-	-	<1%	11–30%	-	-
Seal Rocks South	Atramentous necrosis	*Turbinaria*	-	1	-	-	-	-	-
	Bio-eroding sponge	*Acropora*	-	-	1	-	-	-	1
		Turbinaria	9	7	6	3	4	5	4
		Goniopora	-	-	-	1	-	-	-
		Favites	-	1	1	1	-	-	-
	Bleaching		20–40%	-	-	<1%	6–30%	<1%	-
	Physical		0-1%	-	-	-	-	<1%	-

3.2.12 Coral trends

The overall grade for Coral in the 2026 Gladstone Harbour Report Card was Very Poor (E) for the ninth consecutive year (Figure 3.13). Ongoing monitoring since 2015 further reinforces minimal recovery since the severe loss of coral pre-GHHP monitoring (Table 3.15).

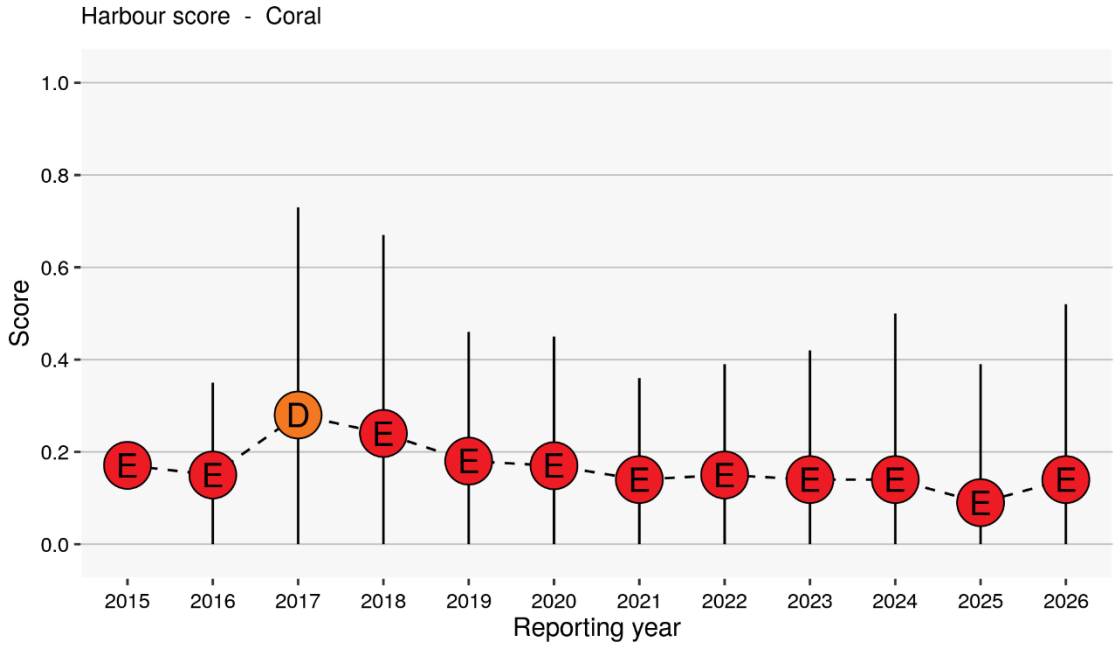

Figure 3.13 | Trends in the overall harbour score for Coral 2015–26 (Error bars show 95% bootstrap confidence intervals). Note, the 2020 score was corrected for an error in change in hard cord cover calculation and differs from the score previously reported on. Refer to 2020 Coral Report or 2020 Technical Report for further detail.

Table 3.14 | A comparison of coral sub-indicator scores for the Mid Harbour and Outer Harbour for surveys conducted from 2015–26.

Zone	2015	2016	2017	2018	2019	2020*	2021	2022	2023	2024	2025	2026
8. Mid Harbour												
Coral cover	0.08	0.05	0.08	0.06	0.09	0.09	0.07	0.06	0.07	0.07	0.05	0.08
Macroalgae cover	0.37	0.10	0.50	0.41	0.02	0.15	0.00	0.07	0.14	0.23	0.19	0.50
Juvenile density	0.23	0.33	0.33	0.34	0.24	0.15	0.15	0.13	0.14	0.14	0.10	0.10
Change in hard coral cover	-	-	0.44	0.30	0.42	0.44	0.43	0.26	0.22	0.23	0.18	0.30
Zone Score	0.23	0.16	0.33	0.27	0.19	0.2	0.16	0.13	0.15	0.13	0.13	0.24
11. Outer Harbour												
Coral cover	0.05	0.09	0.06	0.05	0.07	0.08	0.07	0.12	0.08	0.09	0.06	0.07
Macroalgae cover	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Juvenile density	0.33	0.33	0.44	0.45	0.22	0.08	0.15	0.11	0.00	0.07	0.00	0.06
Change in hard coral cover	-	-	0.37	0.33	0.40	0.39	0.26	0.48	0.40	0.32	0.00	0.00
Zone Score	0.13	0.14	0.21	0.2	0.17	0.14	0.12	0.18	0.14	0.12	0.04	0.12

*Note, 2020 scores shown were corrected for an error in change in hard coral cover calculation and differ from the scores previously reported on. Refer to 2020 Coral Report or 2020 Technical Report for further detail.

3.2.13 Mangroves

Mangroves occur throughout all 13 GHHP environmental reporting zones, forming extensive tidal wetland ecosystems along the Gladstone coastline. These communities are dominated by flowering trees and shrubs that are uniquely adapted to marine and estuarine environments through features such as exposed above-ground breathing roots, salt-excreting leaves, and live water-dispersed propagules (Duke, 2006). Mangroves provide important nursery habitat for fish, prawns and mud crabs, support diverse bird communities, stabilise shorelines, reduce erosion, improve water quality by trapping sediments and nutrients, and store substantial amounts of carbon (UNEP, 2023)

Mangrove and tidal wetland extent within the Port Curtis region has changed over time. Between 1941 and 1999, approximately 38% of mangrove habitat (1,470 ha) and 34% of tidal wetlands (1,342 ha) were lost, largely due to urban expansion, port development and land reclamation, particularly around the Calliope River, Boyne River and Auckland Inlet (Duke et al., 2003). Natural processes, including variations in climate, sediment movement and shoreline dynamics, also influence tidal wetland distribution over time. While these historical changes provide important context, the 1940s distribution is not considered a practical baseline for assessing current condition. Accordingly, the baseline for two mangrove indicators (extent and canopy condition) is determined from the previous assessment (~five-year period) The third indicator, shoreline condition, is based on current conditions.

Long-term report card monitoring has shown that mangroves are generally less responsive to short-term environmental variability than indicators such as seagrass and fish recruitment, which can fluctuate with rainfall and other climatic drivers. Their longevity and resilience make mangroves a stable indicator of environmental condition and more suited to the detection of long-term trends.

Recognising this stability, the GHHP adopted a reduced monitoring frequency for Mangroves from 2019, with assessments conducted every five years rather than annually. The most recent assessment was completed in 2024 and the next is scheduled for 2029. For report cards published between monitoring years, mangrove scores are carried forward from the most recent assessment. The results presented in the 2026 Report Card therefore reflect the findings of the 2024 assessment.

This approach is consistent with other regional report card programs across Queensland, including the Wet Tropics, Dry Tropics and Mackay-Whitsunday partnerships, where indicators that exhibit limited year-to-year variability are monitored less frequently and assessed over longer timeframes (Wet Tropics Healthy Waterways Partnership, 2018; Mackay-Whitsunday Healthy Rivers to Reef Partnership, 2018; Whitehead, 2020).

3.2.14 Mangroves data collection

Mangroves assessment area

Unlike other environmental indicators, which assess aquatic environments within established reporting zones, mangroves focus on tidal wetland ecosystems that were initially outside the 13 GHHP environmental reporting zones. To include mangroves in the reporting, the existing zones have been expanded to cover tidal wetland areas. Since mangrove health can be affected by the surrounding catchment, the expanded zones are divided as needed to align with sub-catchments based on Queensland Government drainage sub-basin areas. This division results in a total of 23 sub-zones (Table 3.16, Figure 3.14). For all mangrove indicators, the zone score is calculated as the average of the sub-zone scores.

Table 3.15 | GHHP environmental reporting zones and Mangrove monitoring sub-zones.

GHHP Environmental monitoring zone	Mangrove monitoring zones
1. The Narrows	1a The Narrows 1b The Narrows
2. Graham Creek	2 Graham Creek
3. Western Basin	3a Western Basin 3b Western Basin
4. Boat Creek	4 Boat Creek
5. Inner Harbour	5a Inner Harbour, Enfield Creek 5b Inner Harbor Barney Point
6. Calliope Estuary	6 Calliope Estuary
7. Auckland Inlet	7 Auckland Inlet
8. Mid Harbour	8a Mid Harbour, Curtis Island 8b Mid Harbour, Facing Island 8c Mid Harbour, West
9. South Trees Inlet	9 South Trees Inlet
10. Boyne Estuary	10 Boyne Estuary
11. Outer Harbour	11a Outer Harbour, Wild Cattle Creek 11b Outer Harbour, Split End
12. Colosseum Inlet	12a Colosseum Inlet, Main 12b Colosseum Inlet, Hummock Hill
13. Rodds Bay	13a Rodds Bay, East 13b Rodds Bay, West 13c Rodds Bay, Pancake Creek 13d Rodds Bay, Hummock Hill

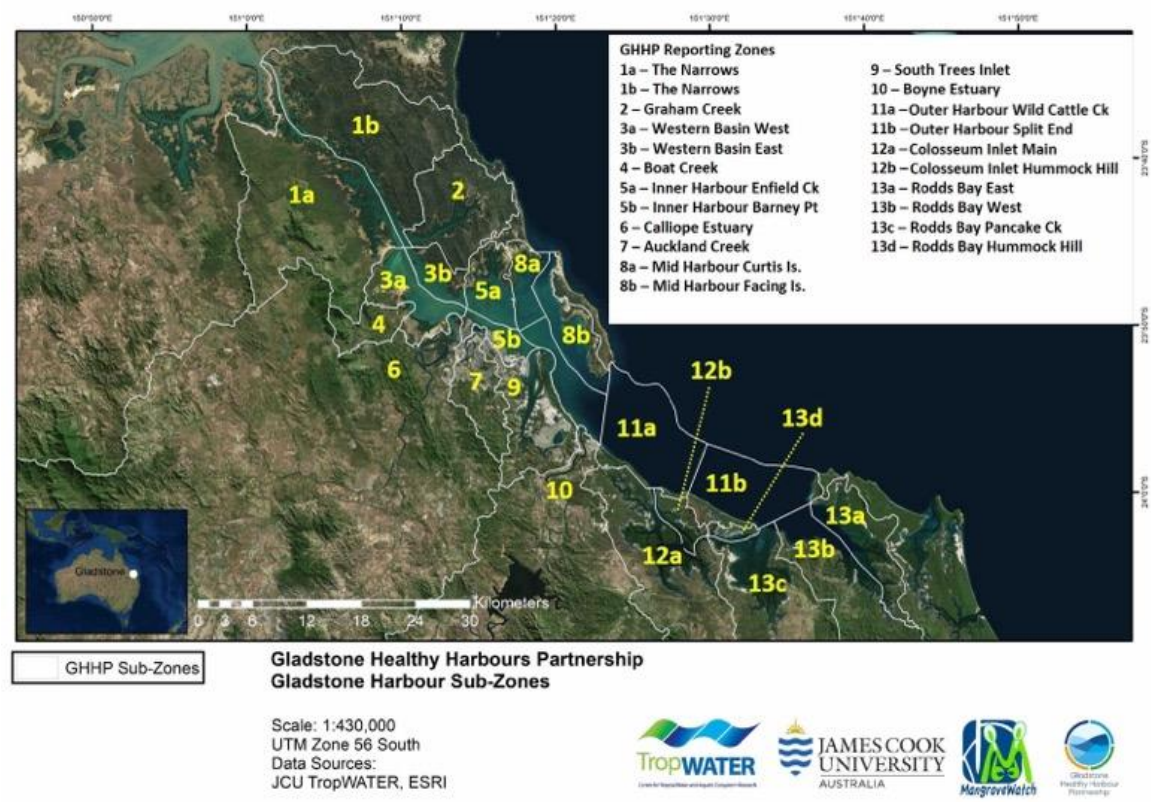

Figure 3.14 | Map showing the 13 GHHP zones and the 23 sub-zones used for mapping of tidal wetland vegetation and the factors influencing them.

Mangroves data collection

All Mangrove data for the report card grades and scores were obtained from 2023–24 satellite imagery (for extent and canopy) or aerial photography (for shoreline), following the Shoreline Video Assessment Method (Mackenzie et al., 2016). Baselines for extent and canopy were based on 2019 satellite imagery, while the shoreline metric was derived from the 2024 aerial imagery (Table 3.17).

Table 3.16 | Mangrove indicators and data used to calculate the 2024 Mangrove grades and scores.

Indicator	2024 data	Baseline data
Extent Change in the WCI from the 5 year mean and the year before	2023–24 satellite imagery (Sentinel 2)	2019 satellite imagery (Landsat 8)
Canopy Variation in NDVI from the 5 year mean and the year before	2023–24 satellite imagery (Sentinel 2)	2019 satellite imagery (Landsat 8)
Shoreline Percent live/dead tress each 50 m interval of mangrove shoreline	May 2024 helicopter filming of 23 sub-zones	No baseline, score calculated statistically (see Table 3.19)

WCI – Wetland cover index. NDVI – Normalised difference vegetation index.

Satellite imagery

To calculate the 2024 scores for the extent and canopy sub-indicators, Sentinel-2 imagery with a 10 m² spatial resolution was used. In previous mangrove assessments, Landsat 8 imagery with a 30 m spatial resolution (Gladstone Harbour: path 91, row 76; Rodds Bay: path 91, row 77) was

used. Masks and models from an earlier study (Duke et al., 2017) were applied to analyse the satellite imagery.

Aerial photography

On 20–21 May 2024, an aerial survey of shorelines bordering the 23 mangrove sub-zones was conducted. A Nikon D800E camera with a 50 mm lens captured overlapping high-resolution photographs of the shoreline. The images were taken from an open R44 helicopter flying at approximately 150 m above the ground, perpendicular to the shoreline.

3.2.15 Development of mangrove indicators and grades

Mangrove extent

Mangroves, salt marsh, and salt pans in tidal wetlands in the Gladstone region typically occupy soft sediment slopes between mean sea level and the highest tide levels. The distribution of each type is influenced by factors such as climate (particularly rainfall) and sea levels. Changes in the extent of these vegetation types, measured by the total area they occupy, are often visible after extreme events like severe flooding, storms, oil spills, or large-scale reclamation (Duke and Mackenzie 2019). However, while such changes are important, they can be challenging to detect, especially along ecotones where different vegetation types converge.

The Wetland Cover Index (WCI) is used to measure the percentage of tidal wetlands occupied by mangroves. It is an important indicator of the hydrological conditions influencing mangrove health. The WCI for each sub-zone was calculated using a Random Forest algorithm, trained on Sentinel-2 satellite imagery. This method employed four specific bands of the imagery and the Normalised Difference Vegetation Index (NDVI) to classify land cover types. Elevation data from the Australian Digital Elevation Model was also included, as elevation influences tidal inundation and, therefore, the distribution of mangroves. Previous assessments used Landsat 8 imagery, but the higher resolution of Sentinel-2 used in 2024 offers improved accuracy.

The 2023–24 data was compared to 2019 to assess changes over time, highlighting areas of mangrove loss or gain. Three key indicators were derived:

- WCI 2023–24
- Extent change score (proportion of mangrove gained between 2019 and 2023–24) derived as:

$$1 - (\text{subzone net change } (\%) - \text{regional net change } (\%))/10$$

Where, the regional net change (%) was 5.39%

- Mangrove loss score (the proportion of mangrove lost between 2019 and 2023–24) derived as:

$$1 - \text{proportion lost}/10$$

The final Mangrove extent score was calculated by averaging these three indicators, first at the sub-zone level, then at the zone level to determine the overall Harbour score.

Table 3.17 | Mangrove extent scoring classification system.

	Very good (A)	Good (B)	Satisfactory (C)	Poor (D)	Very poor (E)
Wetland Cover Index 2024	0.85–1.00	0.65–0.84	0.50–0.64	0.25–0.49	0.00–0.24
Extent change (gain & loss) 2019 to 2024	0–1.5% deviation	1.6–3.5% deviation	3.6–5.0% deviation	5.1–7.5% deviation	> 7.5% deviation
Mangrove loss 2019 to 2024	0–1.5% loss	1.6–3.5% loss	3.6–5.0% loss	5.1–7.5% loss	> 7.5% loss

Canopy condition

The Canopy condition indicator assesses the health of mangrove forests using NDVI. Stress on mangroves reduces productivity and leaf production, potentially leading to tree death if the plants cannot maintain photosynthesis. However, healthy forests can recover when stressors are removed, as surviving trees increase leaf production and seedlings fill gaps left by dead trees. Canopy density reflects overall forest productivity, and resilience is measured by the rate and extent of recovery. Remote sensing helps assess mangrove canopy health by detecting light reflectance, where healthy forests absorb more red light and reflect more near-infrared light.

To evaluate canopy condition, NDVI was calculated for each sub-zone, using satellite imagery for 2023–24 and compared to the 2019 data. The NDVI measures vegetation greenness, with values ranging from -1 to 1. Higher positive values indicate healthier vegetation. For each sub-zone, the mean NDVI and its standard deviation were calculated, along with the proportion of areas where NDVI declined sharply. The minimum mangrove NDVI value was determined to be 0.3 and the maximum value 0.75. In addition to comparing canopy condition between 2019 and 2023–24, a long-term trend assessment was conducted using satellite imagery for the period 2014 to 2023. This data was used to track significant changes in NDVI over time, with major changes indicating shifts in mangrove density.

Two NDVI measures were used to determine the overall canopy condition score for each sub-zone. These scores were then averaged for each reporting zone then aggregated to produce the overall score for the harbour.

1) **2024 NDVI score:** The mean and standard deviation of the annual pixel maximum, or the average NDVI for the greenest days observed in 2023–24.
2) **5-year change:** The five-year mean mangrove NDVI point value between 2019 and 2023–24 NDVI was used to compare temporal change.

Table 3.18 | Classification of canopy condition scores derived from NDVI values 2019 to 2023–24.

	Very good (A)	Good (B)	Satisfactory (C)	Poor (D)	Very poor (E)
Mean NDVI 2023–24	Mean NDVI value 0.81 – 0.73	Mean NDVI value 0.72 – 0.63	Mean NDVI value 0.62 –0.55	Mean NDVI value 0.54 – 0.43	Mean NDVI value 0.42 – 0.30
Mean 5-year NDVI change 2013-14 to 2017–18	Mean inter-annual NDVI difference significantly ($p<0.05$) greater than regional mean and effect size (cohen's d) > 0.70	Mean inter-annual NDVI difference significantly ($p<0.05$) greater than regional mean and effect size (cohen's d) 0.69 to 0.30	Mean inter-annual NDVI difference not significantly ($p>0.05$) different from regional mean. OR Mean inter-annual NDVI difference significantly ($p<0.05$) greater than regional mean and effect size (cohen's d) 0.29 to 0.0	Mean inter-annual NDVI difference significantly ($p<0.05$) less than regional mean and effect size (cohen's d) -0.01 to -0.50	Mean inter-annual NDVI difference significantly ($p<0.05$) less than regional mean and effect size (cohen's d) -0.51 to -1.0

Shoreline condition

Shoreline mangroves play a crucial role in protecting shorelines from severe erosion events and serve as indicators of environmental change. These trees, particularly those at the sea edge (or sea edge ecotone), are exposed to various natural and human stressors, making them effective sentinels for monitoring changes in tidal conditions, water quality, and climate. Given their sensitivity to environmental shifts, shoreline mangroves can quickly reflect alterations in coastal conditions. To monitor their health, the Shoreline Aerial Assessment Method, adapted from earlier approaches (Mackenzie et al. 2016), was developed to assess the condition of mangroves on a large scale. This method matches high resolution oblique aerial photographs with shoreline sampling points at 50 m intervals created from the 0 m contour line using a 5 m Digital Elevation Model (Geoscience Australia, 2020). At each sampling point the presence or absence of individual dead mangroves along the shoreline or within the shoreline fringing zone was noted.

The aerial survey of shorelines bordering the Gladstone Harbour water quality zones took place in May 2024, using high-resolution photographs taken from a helicopter (Figure 3.15). The images focused on identifying dead mature canopy trees at regular intervals along the shoreline, which were used as indicators of mangrove health. Sampling points were spaced 100–150 m apart along the shoreline, aligned with the mean sea level, and the images were analysed to record the presence of dead mangroves. The images were matched to shoreline sampling points using ArcGIS, ensuring precise alignment with the shoreline features. Dead mangroves were identified as either standing or fallen trees in the images. Only dead canopy trees were considered for this assessment. Any images that did not clearly show the shoreline or were improperly matched were discarded.

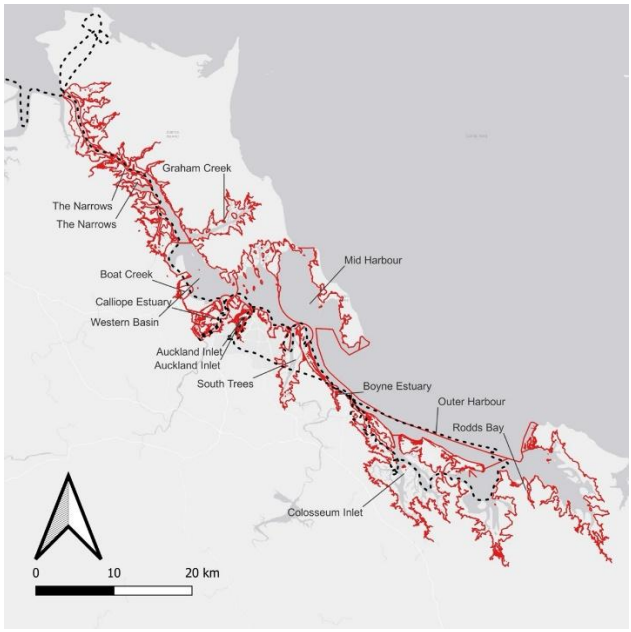

Figure 3.15 | Map showing 13 Gladstone Harbour reporting zones (red lines & labels) and the helicopter track (dashed black line) of the shorelines evaluated using imagery from 2023 (Canning and Duke 2023) for comparison with shorelines assessed in 2018 and 2019.

To derive scores, the frequency of dead mangroves in each GHHP zone was compared using a chi-square goodness of fit test. This analysis aimed to determine whether the frequency of dead mangroves differed significantly across zones compared to the overall study area (Table 3.20). This method provides a quantitative assessment of mangrove health along the shoreline.

Table 3.19 | Classification of shoreline condition scores.

	Very good (A)	Good (B)	Satisfactory (C)	Poor (D)	Very poor (E)
Shoreline condition score (observed dead mangrove frequency)	0–7.5%	7.6–17.5%	17.6–25%	25.1–37.5%	>37.5%
Seasonally adjusted Shoreline Condition Score (relative dead mangrove frequency)	Observed dead mangrove frequency significantly less than expected harbour value ($p<0.05$), Cramer's V 1.0 to 0.7	Observed dead mangrove frequency significantly less than expected harbour value ($p<0.05$), Cramer's V 0.69 to 0.30	Observed dead mangrove frequency not significantly different from expected harbour value ($p<0.05$) OR Observed dead mangrove frequency significantly greater than expected harbour value ($p<0.05$), Cramer's V 0.29 to 0.0	Observed dead mangrove frequency significantly greater than expected harbour value ($p<0.05$), Cramer's V 0.30 to 0.69	Observed dead mangrove frequency significantly greater than expected harbour value ($p<0.05$), Cramer's V 0.7 to 1.0

3.2.16 Mangroves results

In 2026, the overall Mangroves score for Gladstone Harbour was 0.63, receiving a Satisfactory (C) grade. Six zones showed improved grades, four zones declined, and three remained unchanged (Table 3.21). The improvements were largely driven by better Canopy condition scores in eight out of 13 zones, influencing an increase in the overall harbour score (2019: 0.49, 2024: 0.65). Scores for Mangrove extent and Shoreline condition remained stable.

Table 3.20 | Mangrove sub-indicator and indicator scores used in the 2026 Gladstone Harbour Report Card. Scores from 2019 are shown for comparison.

Zone	Mangrove extent	Canopy condition	Shoreline condition	2026*	*2019*
1. The Narrows	0.73	0.76	0.39	0.63	*0.65*
2. Graham Creek	0.83	0.63	N/A	0.73	*0.64*
3. Western Basin	0.64	0.71	0.40	0.65	*0.51*
4. Boat Creek	0.72	0.70	0.54	0.65	*0.46*
5. Inner Harbour	0.40	0.63	0.55	0.56	*0.55*
6. Calliope Estuary	0.90	0.73	0.57	0.73	*0.58*
7. Auckland Inlet	0.67	0.72	0.03	0.47	*0.65*
8. Mid Harbour	0.19	0.59	0.88	0.49	*0.55*
9. South Trees Inlet	0.84	0.65	0.29	0.59	*0.60*
10. Boyne Estuary	0.62	0.48	0.88	0.66	*0.26*
11. Outer Harbour	0.72	0.66	0.68	0.68	*0.66*
12. Colosseum Inlet	0.88	0.60	0.44	0.64	*0.72*
13. Rodds Bay	0.79	0.62	0.78	0.73	*0.64*
Harbour score	0.69	0.65	0.53	0.63	*0.57*

NA – Indicator not assessed due to insufficient data. 2026 scores carried over from 2024 assessment.

Mangrove extent

This indicator is based on changes in mangrove canopy cover from 2019 to 2023–24, relative to saltmarsh and saltpan areas within tidal wetlands. Mangrove extent scores reflect the net gain or loss of mangrove area compared to saltmarsh and saltpan within each sub-zone. Compared to the 2019 assessment, Calliope Estuary improved a grade to Very Good (A), while Colosseum Inlet maintained a Very Good (A) grade. Seven zones achieved Good (B) grades, and two zones received a satisfactory grade, similar to the 2019 results. However, Inner Harbour continued to have Poor (D) grades, and Mid Harbour declined to a Very Poor (E) grade, indicating a net loss of mangrove area compared to the previous year and the five-year baseline (Table 3.22)

In Gladstone Harbour, Sentinel-2 imagery showed a 4.4% increase in Mangrove extent between 2019 and 2023–24. A ten-year comparison using Landsat 8 imagery indicated a 5% increase in Mangrove extent over the past decade, which aligns with periods of high annual rainfall over the past 10 years (Figure 9.4).

Table 3.21 | Wetland cover index, change scores and overall zone scores for mangrove extent.

Zone	Mangrove sub-zone	WCI 2023–24	WCI change score	Mangrove loss score	Sub-zone score	Zone extent score
1. The Narrows	1a. Mainland	0.63	0.81	0.88	0.77	0.73
	1b. Curtis Island	0.63	0.75	0.71	0.69	
2. Graham Creek	2. Graham Creek	0.76	0.85	0.89	0.83	0.83
3. Western Basin	3a. Mainland	0.34	0.39	0.81	0.51	0.64
	3b. Curtis Island	0.52	0.97	0.83	0.77	
4. Boat Creek	4. Boat Creek	0.47	0.87	0.81	0.72	0.72
5. Inner Harbour	5a. Enfield Creek	0.55	0.94	0.90	0.79	0.40
	5b. Barney Point	0.40	-0.42	0.51	0.00	
6. Calliope Estuary	6. Calliope Estuary	0.82	0.99	0.88	0.90	0.90
7. Auckland Inlet	7. Auckland Inlet	0.57	0.94	0.51	0.67	0.67
8. Mid Harbour	8a. Curtis Island	0.34	0.03	0.76	0.37	0.19
	8b. Facing Island	0.26	-0.14	0.74	0.00	
9. South Trees Inlet	9. South Trees Inlet	0.62	0.98	0.91	0.84	0.84
10. Boyne Estuary	10. Boyne Estuary	0.57	0.42	0.86	0.62	0.62
11. Outer Harbour	11a. Wild Cattle Creek	0.50	0.99	0.93	0.81	0.72
	11b. Split End	0.39	0.58	0.93	0.63	
12. Colosseum Inlet	12a Colosseum Creek	0.71	0.98	0.97	0.89	0.88
	12b. Hummock Hill	0.69	0.99	0.97	0.88	
13. Rodds Bay	13a. East	0.74	0.97	0.94	0.88	0.79
	13b. West	0.69	0.87	0.92	0.83	
	13c. Pancake Creek	0.64	0.98	0.94	0.86	
	13d. Hummock Hill	0.41	0.49	0.95	0.61	
Harbour score						0.69

Canopy condition

This indicator was calculated using estimates of the NDVI values for mangrove forest canopies within the 13 environmental reporting zones. Canopy condition improved across the harbour, with eight zones, The Narrows, Graham Creek, Western Basin, Boat Creek, Calliope Estuary, Auckland Inlet, Boyne Estuary and Outer Harbour improving a grade and only one zone, Colosseum Inlet, declining a grade. The scores in the remaining four zones remained stable (Table 3.23).

Despite short term improvements, the long term trends indicate a slight decrease (1.1%) in NDVI over the past 10-years. This decline aligns with annual rainfall trends, as drier conditions over the last decade have corresponded with lower NDVI values (Figure 9.4).

Table 3.22 | Canopy condition, NDVI scores, five-year change and overall scores for canopy condition.

Zone	Mangrove sub-zone	2024 NDVI score	Five-year change	Sub-zone score	Zone score
1. The Narrows	1a. Mainland	0.80	0.74	0.77	0.76
	1b. Curtis Island	0.81	0.69	0.74	
2. Graham Creek	2. Graham Creek	0.78	0.48	0.63	0.63
3. Western Basin	3a. Mainland	0.76	0.59	0.68	0.71
	3b. Curtis Island	0.81	0.69	0.75	
4. Boat Creek	4. Boat Creek	0.75	0.65	0.70	0.70
5. Inner Harbour	5a. Enfield Creek	0.79	0.65	0.72	0.63
	5b. Barney Point	0.66	0.39	0.53	
6. Calliope Estuary	6. Calliope Estuary	0.78	0.68	0.73	0.73
7. Auckland Inlet	7. Auckland Inlet	0.73	0.70	0.72	0.72
8. Mid Harbour	8a. Curtis Island	0.70	0.65	0.68	0.59
	8b. Facing Island	0.69	0.34	0.51	
9. South Trees Inlet	9. South Trees Inlet	0.79	0.51	0.65	0.65
10. Boyne Estuary	10. Boyne Estuary	0.75	0.21	0.48	0.48
11. Outer Harbour	11a. Wild Cattle Creek	0.78	0.45	0.62	0.66
	11b. Split End	0.75	0.65	0.70	
12. Colosseum Inlet	12a Colosseum Creek	0.81	0.45	0.63	0.60
	12b. Hummock Hill	0.82	0.32	0.57	
13. Rodds Bay	13a. East	0.83	0.47	0.65	0.62
	13b. West	0.78	0.54	0.66	
	13c. Pancake Creek	0.82	0.51	0.67	
	13d. Hummock Hill	0.73	0.28	0.50	
Harbour Score					0.65

Shoreline condition

Approximately 700 shoreline points were assessed for the presence of dead mangroves across 12 reporting zones, with shoreline conditions not observed in Graham Creek. The overall proportion of shoreline with dead mangroves increased to 27%, up from 15% in the 2019 assessment. Mid Harbour and Boyne Estuary improved to very good grades (A), while Boat Creek and Outer Harbour saw their grades improve to Satisfactory (C) and Good (B), respectively. Three zones – Western Basin, Inner Harbour and Rodds Bay – remained stable. Auckland Inlet had the highest proportion of dead mangroves (~57%), resulting in a very poor grade (E) with a score of 0.03.

Three other zones also saw their grades decline in 2024 (Table 3.24). Overall, shoreline condition declined slightly by 1.3% between 2019 and 2023–24.

Table 3.23 | Estimates of shoreline condition for harbour environmental monitoring zones and sub-zones.

Zone	Mangrove sub-zone	Dead mangrove frequency score	Seasonally adjusted dead mangrove frequency score	Sub-zone shoreline condition score	Zone shoreline condition score
1. The Narrows	1a. Mainland	0.27	0.41	0.34	0.38
	1b. Curtis Island	0.39	0.47	0.43	
2. Graham Creek	2. Graham Creek	NA	NA	NA	-
3. Western Basin	3a. Mainland	0.35	0.45	0.40	0.40
	3b. Curtis Island	NA	NA	NA	
4. Boat Creek	4. Boat Creek	0.54	0.55	0.54	0.54
5. Inner Harbour	5a. Enfield Creek	NA	NA	NA	0.55
	5b. Barney Point	0.56	0.55	0.55	
6. Calliope Estuary	6. Calliope Estuary	0.59	0.56	0.57	0.57
7. Auckland Inlet	7. Auckland Inlet	-0.14	0.21	0.03	0.03
8. Mid Harbour	8a. Curtis Island	NA	NA	NA	0.88
	8b. Facing Island	1.00	0.76	0.88	
9. South Trees Inlet	9. South Trees Inlet	0.20	0.37	0.29	0.29
10. Boyne Estuary	10. Boyne Estuary	1.00	0.76	0.88	0.88
11. Outer Harbour	11a. Wild Cattle Creek	0.73	0.63	0.68	0.68
	11b. Split End	NA	NA	NA	
12. Colosseum Inlet	12a Colosseum Creek	0.71	0.62	0.66	0.44
	12b. Hummock Hill	0.09	0.36	0.21	
13. Rodds Bay	13a. East	NA	NA	NA	0.78
	13b. West	1.00	0.76	0.88	
	13c. Pancake Creek	0.58	0.56	0.57	
	13d. Hummock Hill	1.00	0.76	0.88	
Harbour score					0.53

NA – Not assessed due to insufficient data

3.2.17 Mangrove discussion

The Mangrove indicators chosen for Gladstone Harbour capture a range of pressures affecting mangroves. These pressures include environmental factors like rainfall variability, rising sea levels, and the impact of floods or storms (cyclones), as well as human activities such as land reclamation, increased sediment and nutrient loads, and localised pollution. These indicators help track trends in mangrove health over time. As the dataset expands, the confidence in these indicators will continue to grow.

In 2023–24, several issues were observed across the study area, with human activities impacting developed shoreline areas near mangroves. The most affected zones were Inner Harbour, Calliope Estuary, Auckland Inlet, Mid Harbour, South Trees Inlet and Boyne Estuary, while Western Basin showed lesser but still notable human influence. These findings were consistent with previous observations from 2018 and 2019. In addition to human-induced changes, natural climatic events,

such as heavy rainfall, storms, and rising sea levels, continued to influence mangrove recovery, which has been slow but steady.

Over the past decade, there was an increase in Mangrove extent across reporting zones. This expansion was linked to long-term rainfall trends. However, a minor decline of Canopy condition (greenness) was also observed, attributed to short-term rainfall fluctuations during the same period. Similarly, Shoreline erosion scores declined between 2019 and 2023, primarily due to a combination of rising sea levels, storms, and human activities, which caused dieback and erosion of shoreline mangrove trees (Figure 3.16 and 3.17).



Figure 3.16 | Shoreline erosion has advanced at Fisherman's Landing in the Western Basin between 2015 (left) and 2024 (right). Photo courtesy of JCU TropWATER.



Figure 3.17 | Shorelines at the mouth of South Trees Inlet showed significant erosion, with the once-living seaward edge of trees visible in 2019 (left) not present in 2024 (right). This erosion has led to further tree death and peat layer disruption. Photo courtesy of JCU TropWATER.

Other observed effects included damage to mangroves along estuarine margins, particularly from flood and erosion events in the Calliope River estuary, and the dieback of upland trees at the upper tidal ecotone due to rising sea levels. Additionally, expansion of mangroves into saltpan areas indicated long-term increases in rainfall, but these changes require further study to fully understand their implications.

3.2.18 Mangroves trends

The overall grade for Mangroves in the 2026 Gladstone Harbour Report Card was Satisfactory (C) (Figure 3.18). Their condition appears to remain stable across the assessed years.

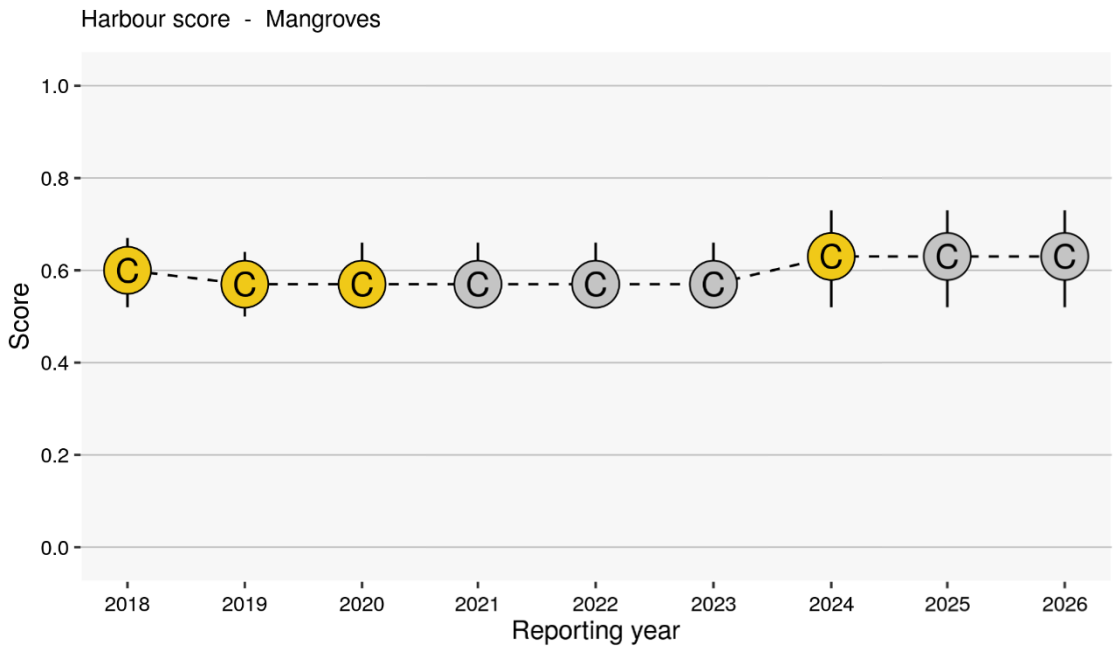

Figure 3.18 | Trends in the overall harbour score for the Mangroves indicator 2018–26 (Error bars show 95% bootstrap confidence intervals). Grey colour represents no new assessment; results carried over from previous assessment.

3.3 Fish and Crabs

3.3.1 Fish health



Figure 3.19 | Fish caught during the BTHU ready to be measured, weighed and tagged. Photo courtesy of Infofish.

Fish are one of the most important social, economic and ecological resources in Gladstone Harbour. As a result, they were identified as a major concern at community workshops conducted by GHHP in 2013 to develop a community-based vision for the Gladstone Harbour Report Card.

Commercial and recreational fishing in Gladstone occurs throughout the harbour and Gladstone hosts annual fishing competitions. Fish play a multitude of roles in aquatic ecosystems including nutrient cycling, ecosystem regulation and bioturbations. They are important in nutrient cycling as they store a large proportion of ecosystem nutrients like phosphorus and nitrogen in their tissue, transport nutrients further than other aquatic animals and the nutrients they excrete are readily available to primary producers such as algae or seagrass. Fish can also play a vital role in ecosystem regulation such as herbivorous fish keeping algae in check on coral reefs.

Two sub-indicators, Fish condition and Fish HAI, contribute to the Fish health indicator. These are assessed by two separate fish monitoring projects:

1. Fish condition (Automated visual assessment using mobile phones and length-weight data)
2. Fish HAI (Gross pathological analysis)

Relying on a citizen science approach for data collection Fish condition provides a less detailed assessment of fish health when compared to the Fish HAI. However, this approach incurs lower costs and by using data collected during fishing competitions like the Australian Bass Tournaments and by recreational fishers (e.g., Gladstone Sportfishing Club), a large portion of the harbour can be assessed at a lower cost than more traditional methods.

Fish condition scores are based on two separate metrics. The first, visual fish condition, is an external assessment of fish health. This includes skin, eyes, fins, parasites and deformities. The second metric is a fish body condition index. This is calculated from length and weight data recorded at the time of capture. Measures of body condition are widely used to assess the health of individual or groups of fish. Generally, fish that are heavier than average for their length are considered healthier with more energy reserves for normal activities including reproduction.

The Fish HAI is a more detailed assessment of fish health which requires a gross pathological assessment during dissection and produces a score based on the condition of several organs and tissues. The index scores add together to reflect the acute and chronic stressors that are present in the fish's environment. A fish with a high Fish HAI score is less healthy than a fish with a low score. Although providing a more rigorous assessment of fish health – owing to the time and expense involved in transporting fish for laboratory analysis – fewer fish are assessed compared to the Fish condition method.

3.3.2 Fish health data collection

Fish mobility

Ideally, the Fish health monitoring program should reflect the prevailing conditions within Gladstone Harbour. Hence fish that remain resident within the harbour provide a more relevant localised measure of conditions than species that have large movements and may be affected by conditions outside of the harbour. The movements of potential target species for the two fish health monitoring programs were assessed in two previous fish health studies which conducted mobility assessments using Suntag fish tag and recapture data provided by Infofish Australia.

Flint et al. (2018), examined the movements of inshore and estuarine fish, that had available tagging data, for six species, including four species assessed for fish health in the 2019 report card (Barramundi, Dusky flathead, Yellowfin bream and Pikey bream). The majority of recorded movements were less than 20 km. Barramundi had the longest movements (mean 8.42 km, maximum 704 km) and the recorded movements of Pikey bream were entirely within Gladstone Harbour.

Sawynok et al. (2018) analysed the movements of four target species; Yellowfin bream, Pikey bream, Dusky flathead and Barred javelin, and found that in these species only 5% of the recorded movements were greater than 5 km.

While the analysis of fish movements demonstrated these species would generally be restricted to the harbour, the recorded movements were still larger than the spatial scale of the 13 environmental monitoring zones. Hence Fish health is scored at the harbour level with a single overall score generated for both projects being applied to all 13 environmental monitoring zones. This single score is because the health of each of the target species can not necessarily be attributed to the conditions within individual environmental monitoring zones. The survey methods for both projects reflect this approach and fish sampling has not been conducted in all 13 zones. However, data for both projects has been collected from north, south and central harbour areas and provides a good spatial coverage that included developed and undeveloped areas. As the location of each fish captured will be recorded it will be possible to identify any fish health 'hot spots' that may occur using this approach.

Fish condition

Data for the Fish condition sub-indicator was collected for six fish species. These are fish that are most likely to be caught during fishing competitions and represent fishes found in a range of environments. They include fish that are bottom dwellers such as Dusky flathead and those that feed higher in the water column. As these species occupy a variety of trophic level and habitats, they may be differentially affected by any fish health issues. For example, demersal or benthic species are in closer contact with pollutants accumulated in sediments and as a result are more likely than pelagic species to present with abnormalities (Cowled, 2016). The target species are:

- Yellowfin bream *A. australis*
- Pikey bream *A. berda*
- Barred javelin *Pomadasys kaakan*
- Dusky flathead *Platycephalus fuscus*
- Mangrove jack *Lutjanus argentimaculatus*
- Barramundi *Lates calcarifer*

Data for Fish condition was collected using the Trackmyfish app (Figure 3.20). The data recorded on the Trackmyfish app included:

- Photos of one side of the fish, preferable on a measuring ruler
- Photos collected by Infofish, both sides of the fish were recorded and assessed
- Total fish length ± 0.05cm

- Tag number from any tagged fish
- GPS location at point of capture, GHHP monitoring zone
- Weight of fish (g) caught for calculation of fish body condition

Data was collected over the course of the 2025–26 reporting year with the aim of collecting a minimum of 325 photographs of the six target species in the Gladstone Harbour environmental reporting area, spread evenly across the 13 environmental monitoring zones (Sawynock et al., 2026). Four methods of data collection were used:

1. Images and length-weights at the live weigh-in section of the Boyne Tannum HookUp (BTHU) fishing competition using the Suntag app (May 2026).
2. Images from Suntag taggers including Gladstone Sportfishing Club members using the Suntag app during normal fishing trips (June 2025–May 2026).
3. Images from the ABT Barramundi tournament in Lake Awoonga using the TMF ABT app (September and November 2025).
4. Length-weights for Barred javelin and Dusky flathead from volunteer Gladstone Sportfishing Club members during normal fishing trips (December 2025–May 2026).

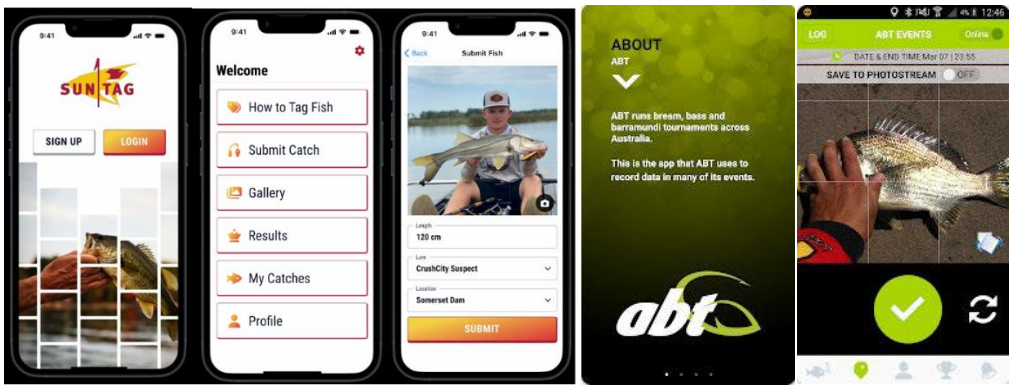

Figure 3.20 | Data for the visual fish condition index was collected Data for the visual fish condition index was collected by fishers using the Suntag app (left) and the ABT Tournament Series app (right).

Over the course of the study period, 1 July 2025 to 30 June 2026, a total of 1760 images of the six target species were captured using the app (Figure 3.21). These images were used to calculate the score for visual fish condition. Human and visual assessments were made for each condition with close to 100% agreement between the two.

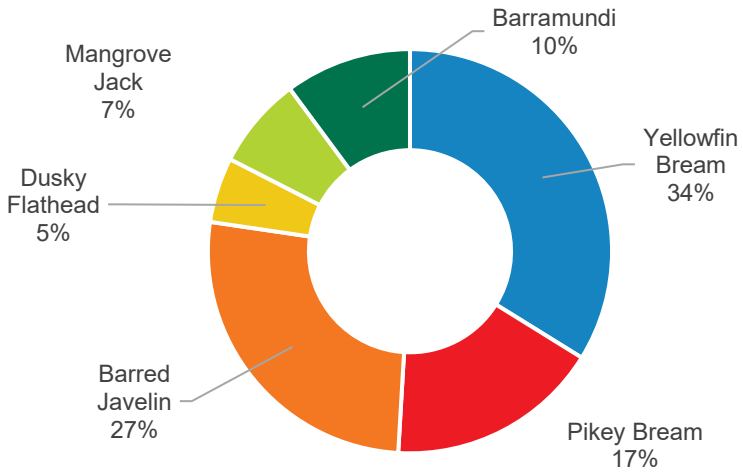

Figure 3.21 | Number of images of each of the six species captured using the Suntag and ABT Apps over the 2026 reporting year.

Data for fish body condition were collected in Gladstone Harbour at the Boyne Tannum HookUp May 2026. Length-weight data from 458 fish were used to calculate the report card scores.

Fish HAI

Based on recommendations from previous fish health studies (Cowled, 2016; Kroon et al., 2016; Flint et al., 2018) and the GHHP Independent Science Panel the following fish species / taxa were identified as target species.

- Barramundi (*L. calcarifer)*
- Bream: Pikey bream (*Acanthopagrus berda)* and Yellowfin bream (*A. australis)*
- Mullet: Diamond scale Mullet (*Liza vaigiensis)* and Sea mullet (*Mugil cephalus)*
- Barred javelin (*Pomadasys kaakan)*
- Dusky flathead (*Platycephalus fuscus)*

These species have been identified as being suitable for biomonitoring on the basis that they are present and abundant, commercially or recreationally fished and spend time low in the water column. Demersal or benthic species are in closer contact with pollutants in sediments and as a result are more likely than pelagic species to present with abnormalities (Cowled, 2016). These species were also caught in sufficient numbers in previous surveys to provide adequate sample sizes for the calculation of report card scores.

In 2025, after review and advice from CQUniversity and the GHHP Independent Science Panel, based on past research efforts in the region a new set of key target species were identified:

- Bream: Pikey bream (*A. berda)* and Yellowfin bream (*A. australis)*
- Barred javelin (*P. kaakan)*
- Blue catfish (*Neoarius graeffei)*
- Sea mullet (*M. cephalus)*

Sampling for Fish HIA was conducted across the 6-day sampling period from April-May 2026 (Anastasi et al., 2026). The surveys in Gladstone Harbour were designed to produce an even catch effort across the northern, central and southern areas of the harbour with a focus on inshore and estuarine sites, this included 11 environmental monitoring zones.

Fish were collected using baited hooks on braided fishing line, with an assortment of bait types purchased from local retailers. Multiple rods were set during each sampling period, with baited hooks set for approximately 20-30 minutes at each site. If no target species were caught during this time, the next site was fished. Mullet were targeted post-wet season using either 50 m long gill nets with stretched mesh sizes of 4.5 inches with an average soak time of 30 min, or by 3 m cast net with 1 inch mesh size.

Captured fish were given a unique identification code and were either processed immediately or kept alive in an aerated swim tank. Bony fish were photographed, measured including length and weight, and the skin, fins and eyes were examined for abnormalities, parasites, lesions or erosion. Sharks and rays were recorded and photographed but were not handled other than to ensure their live release. Non-target fishes were released alive, and target species were euthanised for laboratory analysis. All euthanised fish were individually bagged in an ice slurry and returned to the laboratory on the same day.

3.3.3 Development of Fish health indicators and scoring

Fish condition

Visual fish condition

The visual fish condition measure is based on the HAI developed by Adams et al. (1993). However, unlike the Fish HAI in which the fish is euthanised and both external and internal health parameters are assessed, visual fish condition is based on external indicators of health only and fish are released alive after processing. The five variable conditions assessed are fins, skin, eyes, parasites, and deformities. All parameters are scored between 0 and 30 depending on the severity of the condition with the most severe conditions receiving the highest score (Table 3.25).

To calculate the visual fish condition score for each species, the variable condition scores for each fish were summed and the mean calculated for each species. The harbour wide score was generated by summing the individual species scores and then calculating the average score. All scores were converted to a report card score by standardising the scores to have a range of 0–1.

Table 3.24 | Scoring for five variable conditions used in the visual fish condition measure.

Measure	Variable condition	Score
Fins	No active erosion	0
	Light active erosion	10
	Moderate active erosion with some haemorrhage	20
	Severe active erosion with some haemorrhage	30
Skin	Normal no aberrations	0
	Mild skin aberrations	10
	Moderate skin aberrations	20
	Severe skin aberrations	30
Eyes	No aberrations	0
	Opaque / Milky eye	10
	Swollen eye	20
	Haemorrhaging or bleeding eye	30
	Missing eye	30
Parasites	No parasites	0
	Observed parasites	10
Deformities	No deformity	0
	Observed deformity	10

Fish body condition

Fish body condition was calculated using a relative condition factor. This length-weight relationship is a key measure of fish condition used by fisheries agencies across Australia and internationally (Schneider et al., 2000; King, 2007). The relationship is calculated from the length-weight curve of best fit (Le Cren, 1951) for each of the key species using data recorded in the years from 2003–19 during the BTHU described by the following formula:

$$W = a \times L^b$$

where W is the calculated weight and L is the total length of the fish. Values of W have been calculated from the logarithmic (base 10) equivalent:

$$\log W = \log a + b \cdot \log L$$

The relative condition factor (Kn) (Le Cren, 1951; Koushlesh et al., 2018) is calculated as the proportion of the observed weight (w) to the calculated weight from the length-weight relationship (W) where a condition factor Kn = 1 is consistent with a fish of average condition, Kn >1 being above average and $Kn < 1$ below average.

$$Kn = \frac{w}{W}$$

The minimum (Kn_{min}) and maximum (Kn_{max}) condition factors for the species were determined from the historical minimum and maximum conditions. Each fish is scored (S_{FISH}) by normalising the condition factor, relative to the historical minimum and maximum.

$$S_{FISH} = \frac{Kn - Kn_{min}}{Kn_{max} - Kn_{min}}$$

The final score for the species in the current year is calculated as the average score for the species (where n is the number of fish being assessed) in the current year.

$$S_{FINAL} = \frac{\sum_{i=1}^{n} S_{FISH}}{n} \frac{\sum_{i=1}^{n} S_{FISH}}{n} \frac{\sum_{i=1}^{n} S_{FISH}}{n}$$

Final grades are calculated using the standard Gladstone Harbour Report Card scores (Figure 2.1).

Fish HAI

The HAI was developed by Adams et al. (1993) and included 14 measures of fish health. The Gladstone Harbour Report Card employed a modified Fish HAI which has nine measures of fish health and was used in previous studies in Gladstone Harbour by Wesche et al. (2013). The nine measures include three external measures, four internal organs, and assesses gill condition and parasite load (Table 3.25). The total Fish HAI score was calculated for each individual fish as the sum of the nine measures and the average of the scores was calculated for each species/species group for the harbour. Barramundi, Blue catfish and Barred javelin are reported as individual species. Bream and mullet were analysed as species groups owing to their similar ecological characteristics and to increase sample size. The bream species group includes Pikey and Yellowfin bream, and the mullet species group includes Diamond scale and Sea mullet.

A distance to benchmark method has been employed to calculate report card scores from the average Fish HAI scores. This method involves using a benchmark, best possible condition, and a worst-case scenario. Benchmarks and worse-case scenarios were selected based on existing studies and the data collected during monitoring in 2018–19.

The possible Fish HAI score for an individual fish range from 0–270. However, even in pristine environments a Fish HAI average of 0 is unlikely as fish may have skin abrasions, parasites or slight fin erosion. Conversely, studies employing the Fish HAI (even in polluted environments) have shown that an average score of 270 is equally unlikely (Watson et al., 2012).

Benchmark: In this study, a score of 0 was recorded by 70 of the 223 fish assessed from Gladstone Harbour and five fish from 23 assessed at reference sites also received scores of 0. The occurrence of scores greater than 0 (88%) at the reference sites indicated that even in pristine environments a population score of 0 is unlikely. Hence a pilot benchmark of an average Fish HAI of 10 was used.

Worst Case Scenario: While studies in Gladstone have assessed fish populations in the harbour (Wesche et al., 2013), it is not clear if the HAI values represent a worst-case scenario. Watson et al. (2012) used the full HAI on fish populations in the polluted Loskop Dam and Mamba River in

South Africa and calculated average HAI scores of 113.8 and 108.0. Adjusting these scores to the nine Fish HAI measures used in this study gives maximum scores of 73.2 and 69.4. Based on these results a pilot worst-case scenario was set at an average Fish HAI score of 70.

Scores for the 2026 Gladstone Harbour Report Card were calculated using data from April/May 2026 as follows:

$$1 - \left(\frac{x - B}{WCS - B}\right)$$

Where, x is recorded value, B is benchmark and WCS is worst case scenario.

The 2026 Gladstone Harbour Report Card grade range equates to the following average Fish HAI values:

- Very Good (A) = average HAI of 0–19
- Good (B) = average HAI of 20–31
- Satisfactory (C) = average HAI of 32–40
- Poor (D) = average HAI of 41–55
- Very Poor (E) = average HAI of ≥56

Table 3.25 | Scoring for nine variable conditions used in the Fish HAI in 2026.

Measure	Variable condition	Score
Fins	No active erosion	0
	Light active erosion	10
	Severe active erosion	20
Skin	Normal no aberration	0
	Mild skin aberration	10
	Moderate skin aberration	20
	Severe skin aberration	30
	Extensive redness as a rash. Scales intact	40
Eyes	No aberration, good clear eyes	0
	Fresh haemorrhage (eg net damage)	0
	Opaque eyes (one or both)	30
	Cloudy and swollen, red or haemorrhaging	30
	Ruptured (one or both)	30
Parasites	No observed parasites	0
	Few observed parasites	10
	Moderate parasite infestation	20
	Numerous parasites	30
Spleen	Normal, black, very dark red or red	0
	Normal, granular rough appearance	0
	Nodular, containing fistulas or nodules	30
	Enlarged	30
	Other, aberrations not fitting any above	30
Hindgut	Normal, no inflammation or reddening	0
	Slight inflammation or reddening	10
	Moderate inflammation or reddening	20
	Severe inflammation or reddening	30
Kidney	Normal, firm, dark, flat	0
	Swollen, enlarged or swollen	30
	Mottled, grey discolouration	30
	Granular in appearance and texture	30
	Urolithiasis or nephrocalcinosis	30
	Other, aberrations not fitting any above	30
Liver	Normal, solid red or light red colour	0
	Fatty liver, coffee with cream colouring	30
	Nodules or cysts in liver	30
	Focal discolouration	30
	General discolouration	30
	Other, deviation not fitting any above	30
Gills	Normal no apparent aberration	0
	Frayed, ragged appearance	30
	Clubbed, swelling of tips	30
	Marginate, light discoloured margin	30
	Pale very light colour	30
	Other	30

3.3.4 Fish health results

In 2026, Fish health received a score of 0.78 and a Good (B) grade (Table 3.26). This harbour-wide result is derived from the two Fish health monitoring projects and is applied to all 13 environmental monitoring zones, as zone-specific scores are not calculated.

Table 3.26 | Overall Fish health scores used in the 2026 Gladstone Harbour Report Card.

Indicator	Indicator Score	Overall score
Fish condition	0.86	0.87
Fish HAI	0.88	

Fish condition

The Fish condition score calculated from the mean of the visual fish condition and fish body condition for four species of fish caught in Gladstone Harbour during the 2025–26 reporting year (Table 3.27). Barred javelin, Dusky flathead data were not included in the Fish condition score calculation due to low sample size and insufficient data.

Table 3.27 | Fish condition measures and sub-indicator scores for each of the five fish species

Species	Visual fish condition	Fish body condition	Fish condition
Yellowfin bream	0.97	0.72	0.85
Pikey bream	0.98	0.70	0.84
Barred javelin	0.96	0.52	0.74
Dusky flathead	0.95	NC	0.95
Mangrove jack	0.95	0.69	0.82
Harbour score			0.86

NC – Scores not calculated due to low sample size.

Visual fish condition

From the total sample (n=1760) the detection of visible pathologies was very low: skin issues were detected in four fish (0.1% of total fish), one deformity (0.1% of total fish) and no eye health issues, or detections of external parasites were recorded (Table 3.28). Incidences of fin condition were recorded for all species (Table 3.29). While the rate of incidences was moderate (53%), the severity of this condition was low for most fish and only 0.1% displayed moderate or severe erosion. Only four instances of mild skin aberrations were observed (Table 3.30).

Table 3.28 | Number of visual fish condition incidences detected for six species of fish.

Species	n	Fins	Skin	Eyes	Parasites	Deformities
Yellowfin bream	364	247 (68%)	1 (0.3%)	0	0	0
Pikey bream	184	119 (65%)	0	0	0	0
Barred javelin	284	105 (37%)	0	0	0	1 (0.4%)
Dusky flathead	56	13 (23%)	0	0	0	0
Mangrove jack	79	43 (54%)	0	0	0	0
Barramundi*	109	38 (35%)	3 (3 %)	0	0	0
Total	1076	565 (53%)	4 (0.4%)	0	0	1 (0.1%)

*Not included in the calculation of report card scores for Fish condition owing to the absence of fish body condition data.

Table 3.29 | Fin condition recorded for six species of fish in the 2025–26 reporting year.

Species	n	Condition (Score)			
		No active erosion (0)	Light active erosion (10)	Moderate active erosion with some haemorrhage (20)	Severe active erosion with some haemorrhage (30)
Yellowfin bream	364	117	246	1	0
Pikey bream	184	65	119	0	0
Barred javelin	284	179	99	6	0
Dusky flathead	56	43	13	0	0
Mangrove jack	79	36	43	0	0
Barramundi*	109	71	38	0	0
Total	1076	511	558	7	0

*Not included in the calculation of report card scores for visual fish condition owing to the absence of fish body condition data.

Table 3.30 | Skin condition recorded for six species of fish in the 2025–26 reporting year.

Species	n	Condition (Score)			
		No normal aberrations (0)	Mild skin aberrations (10)	Moderate skin aberrations (20)	Severe skin aberrations (30)
Yellowfin bream	364	363	1	0	0
Pikey bream	184	184	0	0	0
Barred javelin	284	284	0	0	0
Dusky flathead	56	56	0	0	0
Mangrove jack	79	79	0	0	0
Barramundi*	109	106	3	0	0
Total	1076	1072	4	0	0

*Not included in the calculation of report card scores for visual fish condition owing to the absence of fish body condition data.

Fish body condition

Fish body condition is calculated using a Relative Condition Factor (RCF). In 2026, RCF was calculated for 647 fish of the target species (Table 3.31). For fish body condition two species, Pikey bream and Mangrove jack were graded as Good (B), while Yellowfin bream received a Poor (D) grade (Table 3.27). In 2026, no fish body condition data was collected for Barred javelin and Dusky flathead, as these fish species were not included in the BTHU live weight in. Fish body condition was not calculated for Barramundi, as no weight data is available due to lack of images. This limits comparisons with scores from previous years. Figure 3.22 shows the length-weight relationship for Barred javelin, Dusky flathead, Mangrove jack, Pikey bream and Yellowfin bream caught during the BTHU from 2003–26.

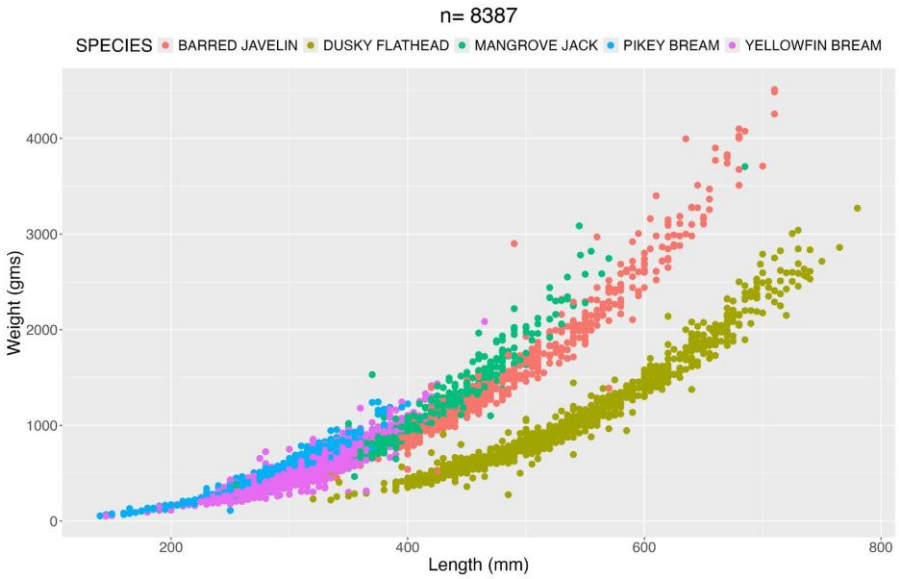

Figure 3.22 | Length-weight relationship for five fish species from the BTHU from 2013–26 (Sawynok et al., 2026).

Table 3.31 | Relative condition factor calculated for five fish species in 2024.

Species	n	Relative condition factor		
		Min	Max	Mean
Yellowfin bream	297	0.841	1.419	1.045
Pikey bream	125	0.442	1.293	1.045
Barred javelin	178	0.568	1.281	1.006
Dusky flathead	15	0.774	1.382	1.089
Mangrove jack	32	0.871	1.168	1.033

Fish HAI

Fish HAI results remained high in 2026, achieving an overall harbour score of 0.88 and maintaining a Very Good (A) grade, although slightly lower than scores recorded in 2025 (0.91) and 2024 (0.90) (Table 3.32). Mullet recorded the highest score of 1.00, while Barred javelin also performed strongly with a score of 0.85. Bream scores declined to 0.50 in 2026 from 0.85 in 2025. Individual HAI scores were not calculated for Barramundi and Blue catfish in 2026 due to insufficient sample sizes; however, their results were included in the overall harbour score.

Table 3.32 | Fish HAI sub-indicator scores for each of the five fish species used in the 2026 Gladstone Harbour Report Card.

Species	2026	*2025*	*2021*
Bream	0.50	*0.85*	0.98
Barred javelin	0.85	*0.94*	0.90
Barramundi	NC	*NC*	0.98
Blue catfish	NC	*0.88*	0.81
Mullet	1.00	*0.98*	0.81
Harbour score	0.88*	*0.91*	0.90

NC – Individual species scores not calculated due to low sample size. *The overall harbour score is based on Fish HAI results across all species and does not represent the average of the individual species scores.

The overall Fish HAI score was the average scores for nine measures (Table 3.33). Internal organ abnormalities contributed most to overall HAI scores in 2026. Bream recorded the highest HAI score (40.0), driven primarily by observations of liver (21.43) and kidney (11.43) abnormalities, along with lower levels of parasites (5.71) and eye abnormalities (1.43). Barred javelin achieved a lower HAI score (19.23), with liver abnormalities (13.85) representing the largest contribution, followed by kidney abnormalities (2.31), eye abnormalities (2.31) and minor parasite loads (0.77). Blue catfish and mullet exhibited very low HAI scores of 5.0 and 3.75 respectively, indicating few observed health issues. No abnormalities were recorded for skin, fins, gills or spleen across any species, suggesting that external signs of poor health were generally absent from sampled fish in 2026.

Table 3.33 | Average measures and Fish HAI total scores for each species caught in Gladstone Harbour in the 2026 reporting year. Organ scores ranged from 0 to 30 and Fish HAI scores ranged from 0 to a possible maximum of 270.

Species	n	Skin	Eyes	Fins	Gills	Spleen	Kidney	Hindgut	Liver	Parasites	HAI score
Bream	21	0	1.43	0	0	0	11.43	0	21.43	5.71	40.00
Barred javelin	13	0	2.31	0	0	0	2.31	0	13.85	0.77	19.23
Blue catfish	2	0	0	0	0	0	0	5.00	0	0	5.00
Mullet	8	0	0	0	0	0	0	0	0	3.75	3.75

3.3.5 Fish health discussion

Visual assessments found very few signs of skin damage, deformities, eye abnormalities, or parasites, with fin wear remaining the most observed issue across species. However, most fin impacts were minor and are likely influenced by handling and capture methods rather than environmental stressors. Fish body condition was generally average to above average for key species, with condition factors exceeding long-term averages for most species assessed.

HAI results similarly indicated that most fish were in good condition, with few external abnormalities and generally healthy organs observed across sampled fish. While Bream recorded higher HAI scores than other target species, reflecting more frequent observations of liver and kidney abnormalities, widespread or severe pathology was not evident. Mullet and Barred javelin exhibited low HAI scores, indicating generally good health.

3.3.6 Fish health trends

Long-term monitoring shows that fish condition outcomes have remained stable over time. Overall harbour Fish health scores have consistently achieved Good (B) grades since 2020 and improved to a Very Good (A) grades in recent monitoring years (Figure 3.23). These results suggest that fish populations continue to support a healthy and resilient harbour ecosystem, although ongoing monitoring remains important to track changes in fish condition and detect any emerging environmental pressures.

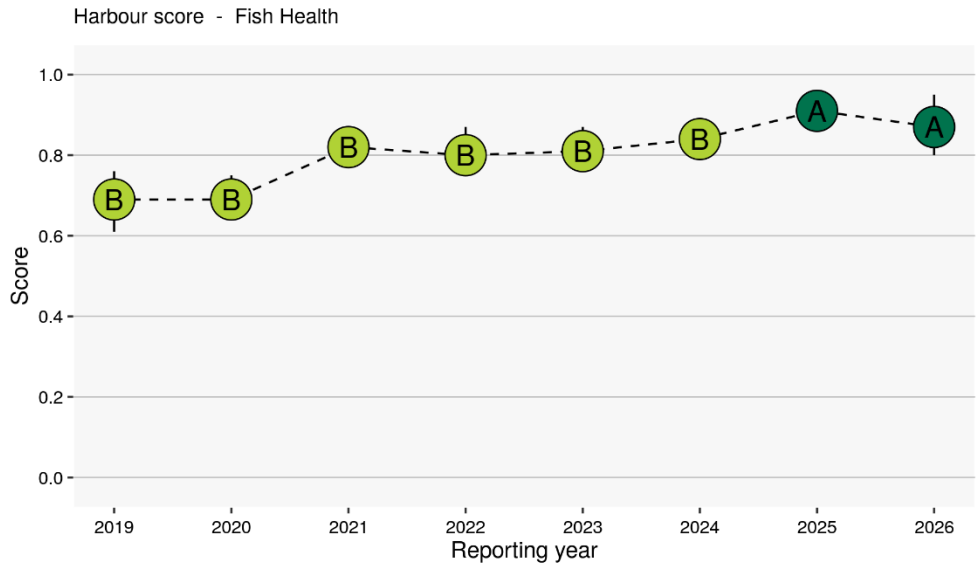

Figure 3.23 | Trends in the overall harbour score for Fish health 2019–26 (Error bars show 95% bootstrap confidence intervals).

3.3.7 Fish recruitment

Fish recruitment is one of the three key dynamic functions that affects a fish population, the other two are growth rate and mortality. The Fish recruitment index is based on the total catch of juveniles of two bream species and is defined as the annual production of juvenile fish entering the mature fish population in Gladstone Harbour (Sawynok and Venables, 2016). The Fish recruitment index captures the reproductive vigour and the spatial extent of two bream species.

A detailed Fish recruitment survey in 2014 helped identify potential species to monitor. Barramundi was considered an unsuitable recruitment indicator for Gladstone Harbour (Venables, 2015), whereas Yellowfin bream *A. australis* and Pikey bream *A. pacificus* (previously known as *A. berda*) were more suitable for long term monitoring. Bream surveys were conducted in the 2025–26 reporting year and data from these surveys are reported below.

What fish were used as indicators of harbour health?

Yellowfin bream

Yellowfin bream is a slow growing (five years to reach 23 cm), silvery bronze body fish endemic to Australia with maximum length of about 60–65 cm. Its home range extends from Townsville (Queensland) to Gippsland Lakes in Victoria. Yellowfin bream inhabit mostly inshore areas and estuaries and forage for small fish, crustaceans, gastropods, bivalve molluscs, polychaete worms and ascidians.

Their spawning mostly occurs near estuary mouths during winter months. Larval stages are then moved to estuaries, develop into small juveniles and live in shallow waters sheltered by seagrass beds and mangrove channels. Yellowfin bream is a protandrous hermaphrodite meaning they undergo sex change during the life cycle.



Juvenile Yellowfin bream
(A. australis)

Pikey bream

Pikey bream is a bottom living dark silvery grey body fish with a maximum length of about 50 cm. In Australia, its home range extends from Darwin (Northern Territory) to Port Clinton in Victoria. This species is not endemic to Australia and also reported in Southern Japan, Southern China, Vietnam, Philippines, Thailand, Malaysia, Indonesia and Papua New Guinea.

Pikey bream inhabit mostly shallow inshore areas and estuaries up to a depth of 50 m. Being benthic feeders, their diet includes crustaceans, amphipods and tanaids. Their spawning mostly occurs in estuarine environment in the months of May-August. Pikey bream is a protandrous hermaphrodite meaning they undergo sex change during the life cycle.



Juvenile Pikey bream
(A. pacificus)

3.3.8 Fish recruitment data collection

Data for the two bream species were collected monthly from 26 sites across 11 harbour zones between December 2025 and February 2026 (Table 3.34). This was the same number of surveys conducted in 2020–21 but a reduction of one month from surveys conducted in previous years (2016–20). The Outer Harbour was excluded from the surveys as there were no suitable bream habitats. From December 2025, Boat Creek was no longer assessed due to challenges accessing the location. Where possible, within each zone, a minimum of two sites were selected to cover the upper tidal limit and another selected within the daily tidal range. Each survey was completed within two weeks, following the largest spring tides as recruitment of fish into nursery habitats is influenced by these large tides. A species fork length up to 100 mm defined juvenile or year 0 recruits (Sawynok and Sawynok, 2026).

Each site was sampled 20 times using a standard cast net (monofilament net with a drop of 2.4 m, mesh size 20 mm and spread of 3.6 m (Figure 3.24). Species were identified in the field and the length of each species, site ID, GPS coordinates, type of substrata, vegetation and site photographs were recorded at each site. Surveys were not done if the water temperature exceeded 32°C (Sawynok and Sawynok, 2026).

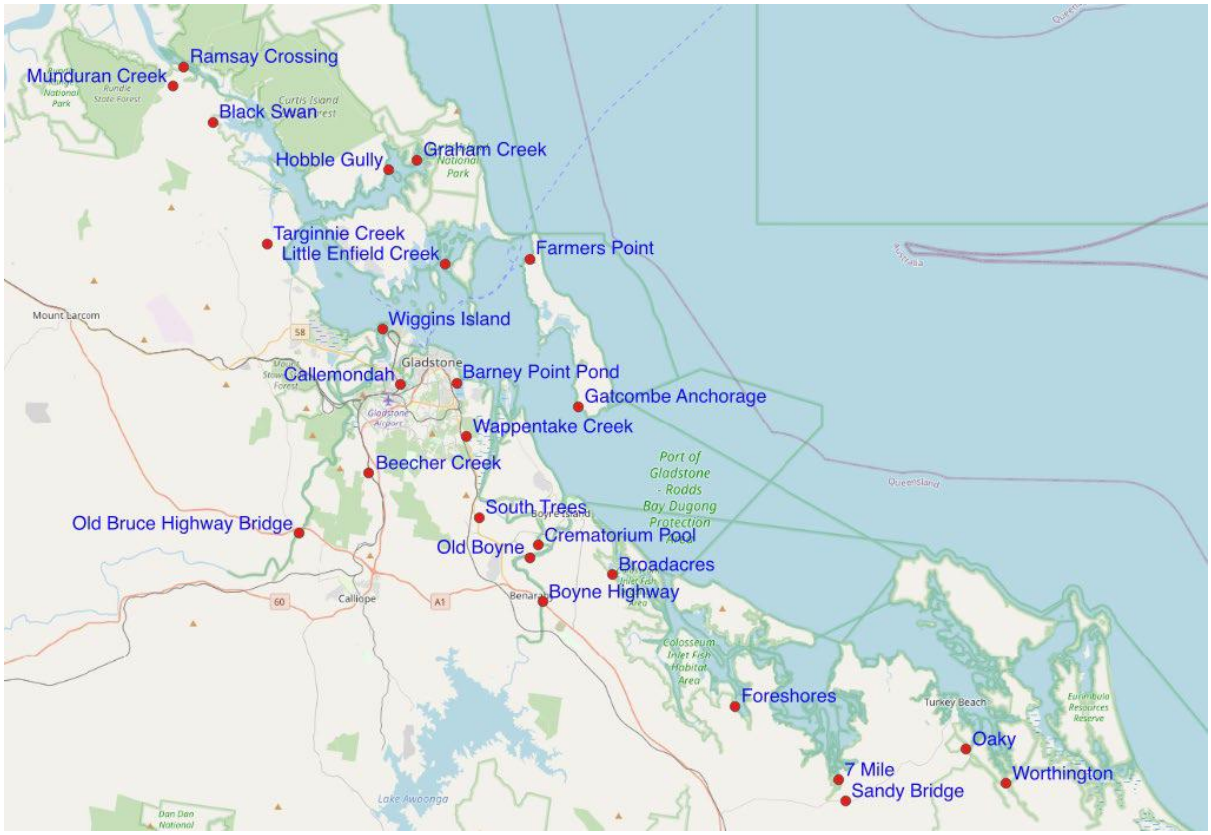

Figure 3.24 | Bream nursery habitats surveyed around Gladstone Harbour in December 2025, January 2026 and February 2026.





Figure 3.25 | Fish recruitment surveys using cast nets (right) and juvenile bream catch sample (left). Photos courtesy of Infofish Australia.

Table 3.34 | Number of sites surveyed and number of juvenile bream caught and released in each monitoring zone in 2023–24.

Zone	Sites	Yellowfin bream	Pikey bream
1. The Narrows	Ramsay Crossing	6	10
	Munduran Creek	7	5
	Black Swan Creek	5	18
	Targinnie Creek	23	7
2. Graham Creek	Graham Creek	1	12
	Hobble Gully	3	33
3. Western Basin	Wiggins Island	49	11
4. Boat Creek	Boat Creek	-	-
5. Inner Harbour	Little Enfield Creek	1	33
	Barney Point Pond	1	0
6. Calliope Estuary	Beecher Creek	17	5
	Old Bruce Highway Bridge	22	3
7. Auckland Inlet	Callemondah	16	29
8. Mid Harbour	Farmers Point	0	0
	Gatcombe Anchorage	5	9
9. South Trees Inlet	Wappentake Creek	0	0
	South Trees	3	21
	Crematorium Pool	34	4
10. Boyne Estuary	Old Boyne	40	15
	Boyne Highway	93	2
12. Colosseum Inlet	Broadacres	2	5
	Foreshores	20	8
13. Rodds Bay	Oaky Creek	15	1
	7 Mile Creek	13	8
	Worthington Creek	19	1
	Sandy Bridge	54	0
Total		449	249

From 2026, Boat Creek sampling ceased due to site access constraints.

3.3.9 Development of Fish recruitment indicators and scoring

A negative binomial statistical model (with a log link) was developed for the catch per trip to a site using data collected for this report card and other historical data collected since 2011. This model assesses the proportional changes in catch rate between years relative to a notional baseline. Several potential environmental predictors related to fish habitats were also tested to determine if

they helped to explain variation in the juvenile catch data. The estimates were aggregated (using the bootstrapping technique) to obtain the report card results.

The final statistical model comprises:

- A response variable – total Yellowfin and Pikey bream juvenile catch count per visit, together with an offset term of log (number of casts), giving an effective response of catch per cast.
- Random effect terms – sampling site (allowing for productivity differences between sites not explained by the fixed effects), year (as the main effect), year by site interaction (to better account for the variability in spatio-temporal scale).
- Log link – allows all difference or changes to be assessed on a proportional or relative scale rather than an absolute one.
- Fixed temporal effects – month term allowing for systematically different catch rates within the survey year.
- Fixed environmental effects – presence and absence of rocks, water depth at a site.

There are no external criteria available to set baseline levels for fish recruitment, therefore the scores were constructed with respect to internal criteria derived objectively from the data (Sawynok and Venables, 2016). A score of 0.50 indicates a season at the median reference level, indicating no increase or decrease in the catch rate from the long-term average.

3.3.10 Fish recruitment results and discussion

Fish recruitment received a Satisfactory (C) grade and an overall harbour score of 0.58 in 2026, a decline from 0.70 in 2025, but similar to scores recorded in 2024 (0.57) and 2022 (0.59) (Table 3.35). Results varied across monitoring zones. Western Basin achieved the highest score (0.88), maintaining consistently strong recruitment levels, while Boyne Estuary also performed well with a score of 0.82. In contrast, The Narrows (0.49), Graham Creek (0.44), South Trees Inlet (0.45) and Colosseum Inlet (0.46) recorded the lowest scores in 2026. Compared with 2025, most zones showed declines, particularly Graham Creek, Colosseum Inlet and Rodds Bay. Auckland Inlet was one of the few zones to improve slightly, increasing from 0.54 in 2025 to 0.59 in 2026. Boat Creek was not assessed in 2026 following the cessation of sampling in this zone due to challenges access the site. Overall, the results indicate spatial variability in fish recruitment across the harbour, with several zones recording lower scores than in recent years.

Table 3.35 | Fish recruitment indicator scores for each zone used in the 2026 Gladstone Harbour Report Card. Results from 2022–25 shown for comparison.

Zone	2026	*2025*	*2024*	*2023*
1. The Narrows	0.49	*0.61*	*0.44*	*0.37*
2. Graham Creek	0.44	*0.68*	*0.54*	*0.53*
3. Western Basin	0.88	*0.89*	*0.82*	*0.77*
4. Boat Creek	N/A	*0.77*	*0.62*	*0.58*
5. Inner Harbour	0.56	*0.76*	*0.77*	*0.58*
6. Calliope Estuary	0.59	*0.65*	*0.50*	*0.28*
7. Auckland Inlet	0.59	*0.54*	*0.36*	*0.36*
8. Mid Harbour	0.59	*0.69*	*0.54*	*0.49*
9. South Trees Inlet	0.45	*0.63*	*0.39*	*0.31*
10. Boyne Estuary	0.82	*0.74*	*0.64*	*0.37*
12. Colosseum Inlet	0.46	*0.67*	*0.68*	*0.41*
13. Rodds Bay	0.55	*0.73*	*0.60*	*0.64*
Harbour score	0.58	*0.70*	*0.57*	*0.47*

N/A – Boat Creek sampling ceased in 2026

The total number of bream caught in 2026 from 1420 casts was 689; comprised of 449 Yellowfin bream and 240 Pikey bream (Table 3.34). For the 2020–24 report cards, the Fish recruitment results were calculated from three surveys (December, January and February), while prior to 2020, there were four surveys conducted (December, January, February and March). The reduction in the number of surveys has had little effect on the overall catch rates per cast (green marker, Figure 3.26).

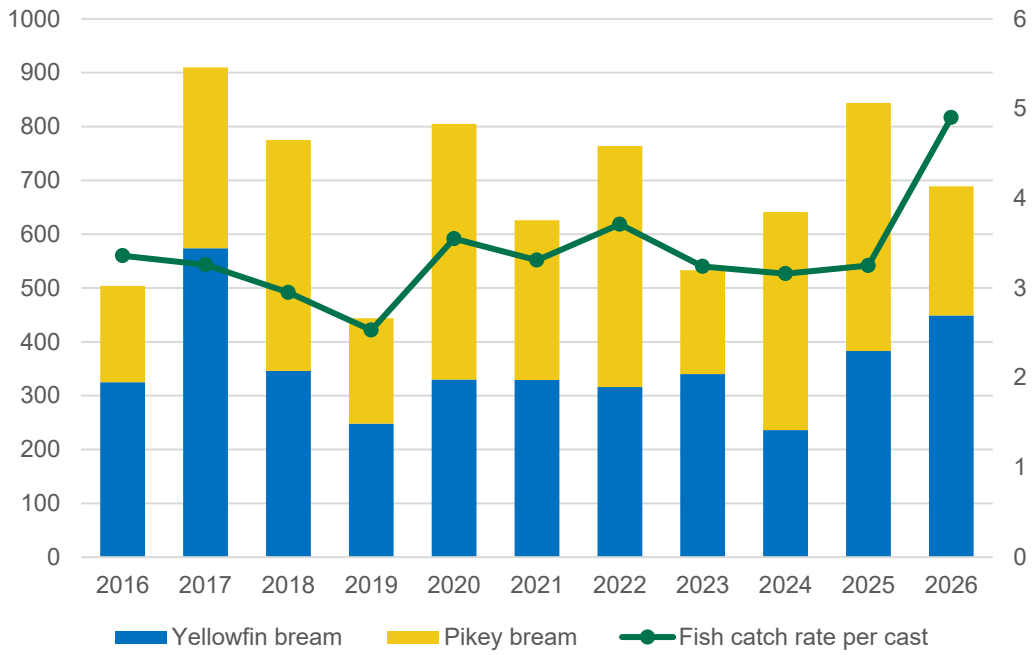

Figure 3.26 | Distribution of Yellowfin and Pikey bream recruits (primary axis) from total bream catch recorded and fish catch rate per cast (secondary axis) during the 2016–26 fish recruitment surveys.

Even though the average catch rates per cast increases, this does not have a direct relationship to the scores (Figure 3.26). The derived final score includes the site level effect and as such is more sensitive to individual site variation than the catch rate. This year, surveys from 2016–17 to 2025–26 were used for year-to-year comparisons, providing 10 years of data based on the same number of surveys over the same time period.

Prawns

In 2026, the number of prawns caught per cast (2025: 1.40) decreased from the previous year (2024: 1.86) but is still a marked increase from the lowest recorded catch rate observed in 2022 (2022: 0.32). The number of prawns this year was highest in the December (n=964) and similar in January (n=490) and February (n=529).

3.3.11 Fish recruitment trends

Fish recruitment declined from a Good (B) grade in 2025 to a Satisfactory (C) grade in 2026 (Figure 3.27), reflecting fewer juvenile fish entering the adult population. The recruitment index, based on catches of juvenile Yellowfin and Pikey bream, measures the reproductive vigour and spatial extent of these species and is a key driver of fish population health. Despite the year-to-year decline, the 2026 result was consistent with the long-term average, indicating stable recruitment conditions across the harbour. While recruitment remains naturally variable, there is no evidence of a long-term declining trend. Strong Yellowfin Bream recruitment helped support the overall result, although Pikey bream recruitment was lower than the previous year's peak.

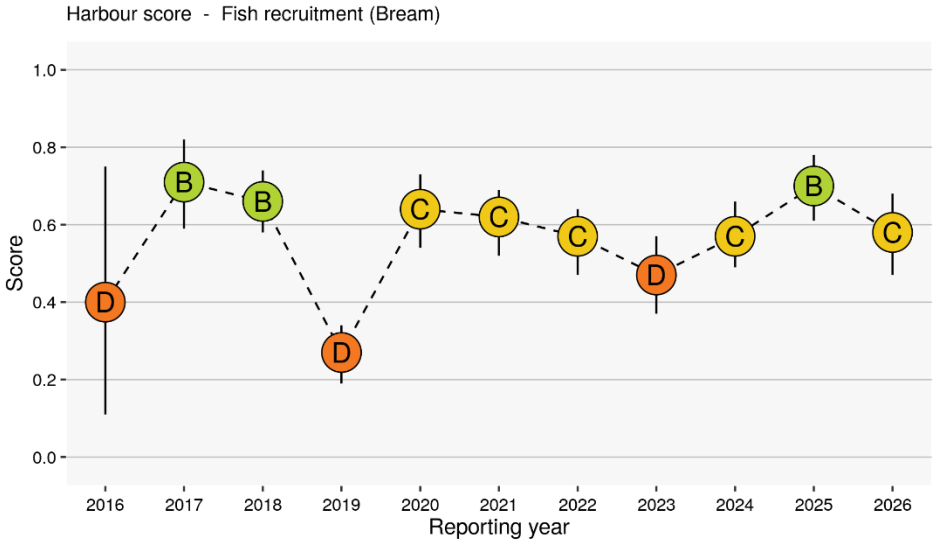

Figure 3.27 | Trends in the overall harbour score for Fish recruitment 2016–26 (Error bars show 95% bootstrap confidence intervals).

3.3.12 Mud crab

Mud crabs are one of Gladstone Harbour's iconic species (Figure 3.28). They were identified as a major community concern at workshops conducted by GHHP in 2013. This is due to their value to commercial and recreational fishers and the reported high rates of rust spot disease in the harbour's population (Andersen et al., 2000). Mud crabs spend most of their post-larval lives in burrows in estuarine mangrove habitats. Their abundance, size distribution and health are related to environmental conditions within these habitats. Based on conceptual models, Dambacher et al. (2013) indicated that the abundance of adult mud crabs was a highly interpretable variable and would be a meaningful indicator for the Gladstone Harbour Report Card.

The Mud crab indicator was developed specifically for the Gladstone Harbour Report Card to establish a long-term mud crab monitoring program that will be sufficiently sensitive to show change over time in response to either natural or anthropogenic pressures, or in response to management actions aimed at improving the health of Gladstone Harbour. A pilot study in 2017 evaluated mud crab monitoring sites and developed suitable indicators of mud crab health and a methodology for determining report card scores.



Figure 3.28 | Mud crab captured in Gladstone Harbour. Photo courtesy of CQUniversity.

3.3.13 Mud crab data collection

Monitoring site selection

Potential monitoring sites were selected based on historical sampling locations such as Queensland Fisheries Long Term Monitoring Program (Jebreen et al., 2008), local knowledge of mud crab populations, accessibility and a reconnaissance trip from 5–6 June 2017. Seven sites were selected for future report card monitoring: The Narrows, Graham Creek, Boat Creek, Inner Harbour, Calliope Estuary, Auckland Inlet and Rodds Bay (Figure 3.29).

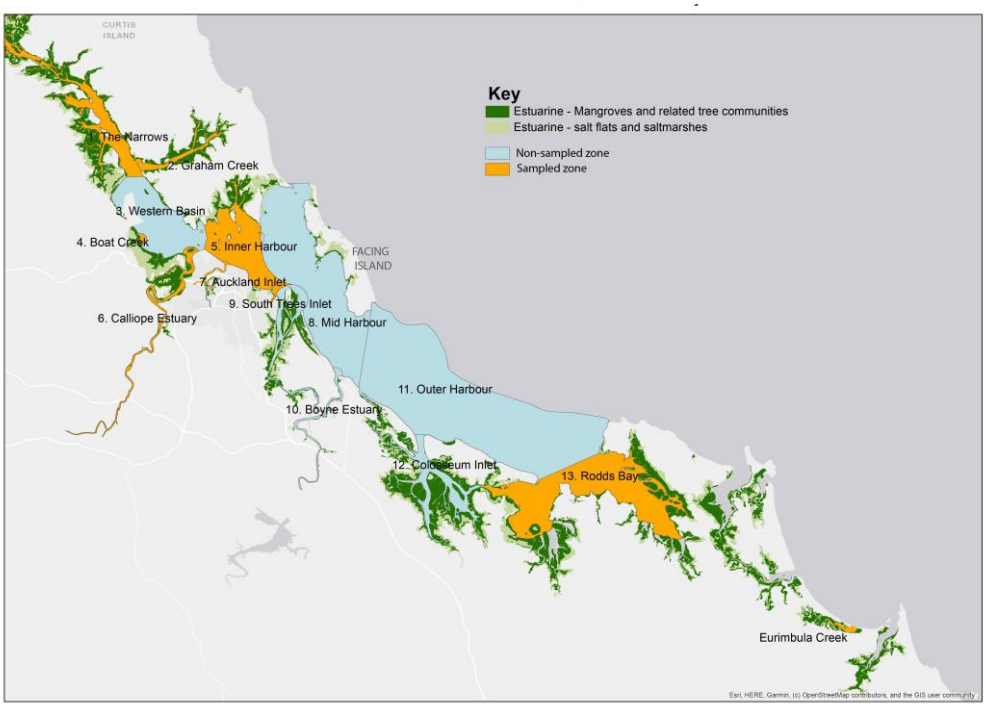

Figure 3.29 | Map of Gladstone Harbour Mud Crab Monitoring Zones. These zones have been surveyed annually from 2017-2024. Eurimbula Creek was sampled in 2018 and 2019 as a reference site.

Mud crab monitoring

Two rounds of Mud crab monitoring were conducted in 2026, a summer (warm, wet season) survey from 27 February to 30 March 2026 and a winter (cool, dry season) survey from 10–12 June 2026 (Flint et al., 2026).

Twenty heavy-duty, four-entry collapsible crab pots were set at a minimum of 100 m apart at each site. The exception was Boat Creek where fewer pots could be placed within the confines of this small zone. Sampling dates and times were determined by tidal cycles. The baited crab pots were set at least three hours before the low tide, and collected at least two hours after the low tide, resulting in soak times of approximately five hours per pot. All pots were placed so that they would be submerged for the duration of deployment to prevent mortality of any fish or other bycatch. Pots were placed as close as possible to mangrove habitats within this limit.

Upon retrieval of the pots, the following data were collected at each site for mud crabs:

- Species
- Sex
- Carapace width (notch to notch; mm)
- Abnormalities: type, body location and number, dimensions and grade of rust spot lesions (Andersen and Norton, 2001)

For all bycatch (crabs and fish), the species was recorded. Blue swimmer crabs were also weighed, measured and checked for abnormalities. All mud crabs and bycatch were released alive at the site of capture. Used baits were kept on board the vessel and not discarded at the sampling site. This was to reduce interference with commercial and recreational mud crabbers in the area.

3.3.14 Development of Mud crab indicators and scoring

A literature search for potential Mud crab indicators identified nine classes of potential indicators (Table 3.37). This included the three sub-indicators identified by the GHHP Independent Science Panel for consideration: abundance, size distribution and visual health (McIntosh et al., 2014). Other potential indicators were identified in the literature or were those used in other mud crab surveys in the Gladstone area.

Table 3.36 | Potential Mud crab indicators were identified and ranked based on their suitability for calculating report card scores.

Potential Mud crab indicator measures	**Total score (30 = highest possible score)**
Size:Sex ratio *sex ratio based on legal size limit*	26.5
Biomass *ratio of carapace width to body weight*	25.3
Abundance *catch per unit effort (CPUE)*	25
Prevalence of rust lesions *visual assessment*	24
Bioaccumulation of toxicants *bioaccumulation of metals in tissues* *structural deformities of organs (associated with metals)* *bioaccumulation of persistent organic pollutants* *bioaccumulation of pesticides*	21.3
Nursery value *juvenile crabs (CPUE*)	18
Morphometrics *e.g. claw size ratio*	18
Prevalence of other diseases and parasites visual assessment	17.5
Biomarkers *Glutathione S-transferases induction and ChE inhibition* *RNA/DNA ratios* *glutathione peroxidase activity and lipid peroxides* *antioxidant enzymes and oxidative stress parameters*	14

The potential indicators were scored against 10 criteria by the project team (Flint et al., 2017a) and three indicators were selected for the report card:

1. Abundance: CPUE

$$\frac{(total\ number\ of\ mud\ crabs\ caught)}{(number\ of\ pots\ set)}$$

1. Prevalence of rust lesions

$$\frac{(number\ of\ mud\ crab\ with\ lesions)}{(number\ of\ mud\ crabs\ assessed\ for\ lesions)}$$

2. Sex ratio: based on legal size limit

$$\frac{(number\ of\ male\ mud\ crabs\ > 150\ mm\ carapace\ width)}{(number\ of\ female\ mud\ crabs\ > 150\ mm\ carapace\ width)}$$

The Gladstone Harbour Report Card scores were calculated using a methodology similar to that used in the South East Queensland Report Card (Fox, 2013) and the Fitzroy Basin Report Card (Flint et al., 2017b). The indices for sex ratio, abundance and visual health were calculated and compared to a benchmark and a worst-case scenario (Table 3.38). Calculated index values lower than the worst-case scenario scored 0; values higher than the benchmark value scored 1. This resulted in a range of scores between 0 and 1. Benchmarks and worse-case scenarios were selected based on existing data and data collected during the 2017 report card monitoring.

A potential fourth sub-indicator (biomass) was previously considered. Owing to a lack of baseline data, biomass was not included in the 2017 or 2018 report cards. In 2019, the GHHP Independent Science Panel discussed the potential inclusion of biomass as there was three years of baseline data; however, recommended that biomass not be included due to complications in assessment.

Table 3.37 | Calculation of Mud crab scores for the 2026 Gladstone Harbour Report Card.

Measure	Benchmark	Worst-case scenario	Method
Abundance (CPUE)	**1.3** *Moving average of 75th percentile of the combined 2017–24 scores*	**0.25** *Catch rate of < 1 crab per allowable 4 pots*	$1-((x-B)/(WCS-B))$ Where: x=recorded CPUE B=benchmark (1.3) WCS=worst-case scenario (0.25)
Prevalence of rust lesions	**0.04** *25th percentile of the 2017 data (4%)*	**0.35** *Prevalence recorded by Dennis et al. (2016) in Gladstone Harbour of 37%, rounded down to 35%*	$1-((x-B)/(WCS-B))$ Where: x=recorded prevalence B=benchmark (0.04) WCS=worst-case scenario (0.35)
Sex ratio	**2** *Male to female sex ratio of 2:1 from an unfished Central Queensland population at Eurimbula Creek (Flint et al., 2019)*	**0.25** *25th percentile of Long-Term Monitoring Program data*	$1-((x-B)/(WCS-B))$ Where: x=recorded ratio B=benchmark (2) WCS=worst-case scenario (0.25)

The sex ratio measure assessed fishing pressure, as only male crabs can be retained. A minimally disturbed benchmark requires data from an unfished population, where an undisturbed male to female crab ratio can be determined. The 2017 benchmark was set at 3:1 based on unfished populations in Micronesia (Alberts-Hubatsch et al., 2016). In 2018, the sex ratio benchmark was updated to 2:1 using data from unfished populations in northern NSW and an unfished section of Moreton Bay (Butcher, 2004; Pillans et al., 2005). In 2018–19, a GHHP-funded CQU study investigated the sex ratio from a more local population in Eurimbula Creek (an un-crabbed estuary in Central Queensland). Findings from this study corroborate the previously reported sex ratio benchmark of 2:1 (Flint et al., 2019). As the AIMS Long-Term Monitoring Program data are the

longest time series available, the worst-case scenario was set from this data at the 25th percentile (0.25).

Abundance was indirectly measured as CPUE – total catch divided by the number of pots within each of the seven monitoring zones. The benchmark for abundance (measured as CPUE) was set as the 75th percentile of the past three years. An accumulating average of the 75th percentile will be used for up to 10 years to account for natural variability. Using the accumulating average from 2017–24, the benchmark for 2024 was 1.3 crabs/pot. The worst-case value was set at 0.25, equivalent to one crab from four pots. The maximum number of pots that a recreational crabber is allowed is four and a catch of less than one mud crab from four pots is undesirable.

The benchmark and worst-case scenario for the prevalence of rust lesions was set using historical data (e.g. Andersen et al., 2000; Dennis et al., 2016). A background level of 5% of crabs with rust spot lesions has previously been reported. However, the 25th percentile of the 2017 monitoring was approximately 4% (0.04) and this lower figure was adopted as the benchmark as a precautionary approach. The worst-case scenario (0.35) was based on a study by Dennis et al. (2016), which was conducted at a time of unusually high fish and crab disease and is representative of a population in poor condition.

In 2020, the GHHP Independent Science Panel recommended a change in Mud crab scoring methodology which was approved by the GHHP Management Committee. Boot-strapping processes described in Section 2.1 aside, calculation of the harbour score for Mud crabs is as follows:

- Calculate the scores for each sub-indicator in each zone
- Average the scores of the sub-indicators to get a harbour score for each sub-indicator
- Average the sub-indicator harbour scores to get the overall harbour score.

Previously the harbour score was derived by averaging the zone scores. This had the effect of omitting zones in which an insufficient catch ($n < 5$) occurred. Under the new method, the zero for abundance is captured for zones with an insufficient catch in the abundance sub-indicator score, which is then averaged with the prevalence of rust lesions and sex ratio sub-indicator scores to calculate the overall harbour score.

3.3.15 Mud crab results

The Mud Crab indicator achieved an overall harbour score of 0.51, corresponding to a Satisfactory (C) grade in 2026 (Table 3.38). This represents a slight decline from 0.54 in 2025 but remains higher than the score recorded in 2024 (0.48).

Abundance (CPUE) was the lowest scoring sub-indicator with a score of 0.38, resulting in a Satisfactory (C) grade. The Narrows (0.84), Boat Creek (1.00) and Calliope Estuary (0.76) recorded the highest abundance scores, while Graham Creek, Inner Harbour and Auckland Inlet all scored 0.00, reflecting very low catch rates relative to the harbour benchmark.

The sex ratio sub-indicator received an overall score of 0.42, corresponding to a Satisfactory (C) grade. Scores varied among zones, ranging from 1.00 in Rodds Bay to 0.00 in Inner Harbour. Most zones recorded lower-than-expected ratios of legal-sized males relative to females, which reduced overall performance.

Among the three sub-indicators, prevalence of rust lesions was the strongest performer, achieving a harbour score of 0.72 and a Good (B) grade. Several zones recorded very high scores, including Graham Creek and Rodds Bay (both 1.00), indicating a low prevalence of rust lesions in captured crabs. Lower scores were recorded in The Narrows (0.51), Inner Harbour (0.48) and Auckland Inlet (0.32).

Table 3.38 | Mud crab sub-indicator and indicator scores for the 2026 Gladstone Harbour Report Card.

Zone	Abundance (CPUE)	Sex ratio	Prevalence of rust lesions	2026	*2025*	*2024*
1. The Narrows	0.84	0.57	0.51	0.64	*0.87*	*0.65*
2. Graham Creek	0.00	0.57	1.00	0.52	*0.35*	*0.31*
4. Boat Creek	1.00	0.05	0.85	0.63	*0.74*	*0.75*
5. Inner Harbour	0.00	0.00	0.48	0.16	*0.68*	*0.42*
6. Calliope Estuary	0.76	0.11	0.87	0.58	*0.27*	*0.38*
7. Auckland Inlet	0.00	0.62	0.32	0.31	*0.41*	*0.38*
13. Rodds Bay	0.08	1.00	1.00	0.69	*0.44*	*0.38*
Harbour score	0.38	0.42	0.72	0.51	*0.54*	*0.48*

CPUE – catch per unit effort

Abundance

A total of 197 mud crabs were captured across the seven monitoring zones in 2026, comprising 62 crabs during the summer survey (February/March) and 135 during the winter survey (June) (Table 3.39). Winter catches were notably higher than those recorded over the previous three years, indicating an improvement in overall catch rates.

Boat Creek recorded the highest abundance, with a combined CPUE of 2.53 and an abundance score of 1.00, exceeding the harbour benchmark. Strong catches were also recorded in The Narrows (CPUE 1.05; score 0.84) and Calliope Estuary (CPUE 0.97; score 0.76). In contrast, Inner Harbour (CPUE 0.13), Auckland Inlet (CPUE 0.20), Graham Creek (CPUE 0.25) and Rodds Bay (CPUE 0.33) recorded comparatively low catch rates and correspondingly low abundance scores.

The overall harbour abundance score was 0.38, equivalent to a Satisfactory (C) grade. This represents an improvement compared with 2024 and 2025 and continues a gradual increase in abundance observed over the past three years.

Table 3.39 | Catch per unit effort for pots set in seven harbour zones during the 2026 Mud crab surveys.

Zone name	Feb/Mar 2026			Jun 2026		
	Pots	Crabs caught	CPUE	Pots	Crabs caught	CPUE
1. The Narrows	20	11	0.55	20	31	1.55
2. Graham Creek	20	3	0.15	20	7	0.35
4. Boat Creek	16	24	1.50	16	57	3.56
5. Inner Harbour	20	2	0.10	20	3	0.15
6. Calliope Estuary	20	20	1.00	19*	18	0.95
7. Auckland Inlet	20	1	0.05	20	7	0.35
13. Rodds Bay	20	1	0.05	20	12	0.60

CPUE – Catch per unit effort. * One pot was found to be missing from Calliope Estuary during retrieval.

Rust lesions

21 of the 197 mud crabs captured in 2026 exhibited rust shell lesions, resulting in a harbour-wide rust lesion score of 0.72 and a Good (B) grade (Table 3.40). This was the highest-performing of the three mud crab sub-indicators.

The prevalence of rust lesions varied among zones. Graham Creek and Rodds Bay recorded no rust lesions and achieved the highest scores of 1.00. High scores were also recorded at Boat Creek (0.85) and Calliope Estuary (0.87). Lower scores were observed in The Narrows (0.51), Inner Harbour (0.48) and Auckland Inlet (0.32), reflecting a greater proportion of affected individuals at these locations.

Although rust lesion prevalence remained low overall, the number of affected crabs increased from 11 in 2025 and three in 2024 to 21 in 2026, continuing a recent upward trend.

Table 3.40 | Number and percentage of mud crabs with rust spot lesions caught in Feb/Mar and Jun 2026, by zone.

Zone name	Feb/Mar 2026		Jun 2026	
	# with lesions	% with lesions	# with lesions	% with lesions
1. The Narrows	3	27.3	31	16.13
2. Graham Creek	0	0	7	0
4. Boat Creek	2	8.3	57	8.77
5. Inner Harbour	1	50.0	3	0
6. Calliope Estuary	2	10.0	18	5.56
7. Auckland Inlet	0	0	7	28.57
13. Rodds Bay	0	0	12	0

Sex ratio

A total of 102 mud crabs larger than the legal male size limit were recorded during 2026 monitoring, including 47 males and 55 females. The overall harbour wide sex ratio score was 0.42, corresponding to a Satisfactory (C) grade (Table 3.41).

Sex ratios remained below the benchmark of 2:1 males to females in most zones. The Narrows recorded the highest ratio (1.25:1), while Graham Creek recorded a similar ratio of 1.25:1 and Auckland Inlet recorded 1.33:1. Lower ratios were observed in Boat Creek (0.33:1), Calliope Estuary (0.44:1) and Inner Harbour, where no male crabs above the legal size limit were captured.

Rodds Bay was the only zone to exceed the benchmark, recording a ratio of 5:1 males to females. However, this result was based on a small sample size of only 12 legal-sized crabs.

Table 3.41 | Sex ratio of legal-sized mud crabs (carapace width >150 mm) in Feb/Mar and Jun 2026 by zone.

Zone name	Feb/Mar 2026			Jun 2026		
	Males	Females	Sex ratio	Males	Females	Sex ratio
1. The Narrows	4	5	0.80	11	7	1.57
2. Graham Creek	1	1	1.00	4	3	1.33
4. Boat Creek	1	9	0.11	4	6	0.67
5. Inner Harbour	0	0	NC	0	1	0.00
6. Calliope Estuary	6	9	0.67	2	9	0.22
7. Auckland Inlet	1	0	NC	3	3	1.00
13. Rodds Bay	0	0	0.20	10	2	5.00

NC – not calculated owing to inadequate sample size (n < 5). Note figures for sex ratio represent actual male-to-female crab ratios and not Gladstone Harbour report card scores.

3.3.16 Mud crab discussion

The Mud crab indicator achieved an overall harbour score of 0.51 and a Satisfactory (C) grade in 2026, representing a slight decline from 2025 (0.54) but an improvement on 2024 (0.46). Results indicate that Gladstone Harbour continues to support productive mud crab populations, although performance varied across the three sub-indicators.

Abundance was the lowest-scoring sub-indicator, despite showing signs of recovery. Catch rates have increased steadily over the past three years following a period of low catches. Strong performance at The Narrows, Boat Creek and Calliope Estuary contributed positively to overall harbour scores, while persistently low catches in Graham Creek, Inner Harbour and Auckland Inlet reduced overall performance. Given the many environmental and biological factors that influence mud crab abundance, including habitat availability, recruitment success, weather conditions and fishing pressure, continued long-term monitoring remains critical for distinguishing natural variability from longer-term population trends.

Sex ratio remained below the benchmark across most zones, indicating that large female mud crabs continue to outnumber legal-sized males within much of the harbour. As Queensland fisheries regulations allow the harvest of legal-sized males but protect all females, fishing pressure is likely an important factor influencing these patterns. While Rodds Bay recorded a highly favourable sex ratio, the small sample size limits confidence in this result. The return to more typical sex ratio patterns following the unusually high harbour-wide score observed in 2025 suggests that the previous year's result was likely influenced by short-term variability rather than a sustained change in population structure. Presently, the timing and population effect of the female spawning migration is not well understood and the possibility that this may be influencing the observed scores cannot be ruled out (Flint et al. 2024). In addition to changes in population dynamics, sex ratio may impact ecosystem processes owing to differences in behaviour between male and female crabs. For example, only male crabs dig burrows, a behaviour which may aid the process of bioturbation (disturbance of sedimentary deposits by living organisms) in mangrove ecosystems. Research is required to understand how a changed sex ratio impacts the health of mud crab populations.

Rust lesions remained the strongest-performing sub-indicator and generally indicate a low prevalence of disease across much of the harbour. However, there has been an increase in affected crabs over recent years. While the causes of rust lesions have not been conclusively determined, their historical association with environmental disturbances and their increasing prevalence highlight the importance of ongoing monitoring and further research to better understand their drivers. The prevalence of rust lesions was scored with moderately high confidence in the benchmark and worst-case scenario as they are based on research data from Gladstone Harbour (Andersen and Norton, 2001; Dennis et al., 2016) and data collected during the 2017 GHHP monitoring year. These scores indicate a very low prevalence of rust spot lesions across the harbour.

Overall, the 2026 results reflect stable mud crab populations with improving abundance, continued skewing of sex ratios towards females and generally low but increasing prevalence of rust lesions. The continuation of this decade-long monitoring program provides valuable for tracking long-term changes in mud crab populations.

3.3.1 Mud crab trends

The Mud Crab indicator has shown moderate year-to-year variability over the past decade, with harbour scores ranging from 0.39 to 0.55 (Figure 3.30). Mud crab declined from a Satisfactory (C) grade in 2017 to a Poor (D) grade between 2019 and 2022. Since 2022, results have generally improved, with the indicator returning to a Satisfactory (C) grade in 2023 (0.51). Despite annual fluctuations, the long-term trend suggests stable mud crab condition across the harbour, with the indicator remaining within the Satisfactory (C) grade range in three of the last four reporting years.

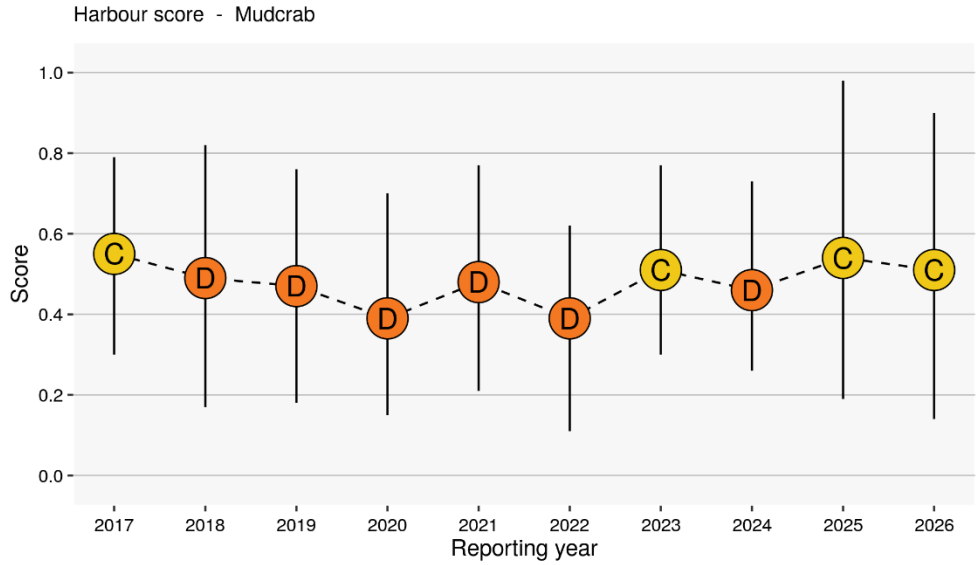

Figure 3.30 | Trends in the overall harbour score for Mud crab 2017–26 (Error bars show 95% bootstrap confidence intervals).

3.4 Overall Environmental results

The overall Environmental score declined slightly from 0.70 in 2025 to 0.68 in 2026, yet maintaining a Good (B) grade (Table 3.42 and Figure 3.31). These results reflect the continued strong performance of Water and Sediment Quality across Gladstone Harbour, alongside stable Habitat condition and mixed results for Fish and Crab populations.

The Water and Sediment Quality indicator group remained one of the strongest-performing environmental indicators, achieving a Very Good (A) grade for the tenth consecutive year. While the Water quality score declined slightly from 0.79 to 0.75, it retained a Good (B) grade, reflecting healthy water quality conditions across the harbour. Sediment quality continued to perform exceptionally well, maintaining a Very Good (A) grade with a score of 0.96, unchanged from the previous assessment.

The Habitats indicator group retained a Satisfactory (C) grade, with an overall score similar to the previous year. Seagrass condition remained strong, achieving a Good (B) grade despite a slight decline in score in 2026 of 0.78 from 0.81. Coral continues to receive low with scores (0.14) and a Very Poor (E) grade, although there was a small improvement from the previous assessment in 2025 of 0.09. Mangrove condition was carried over from the most recent assessment and remained at a Satisfactory (C) grade.

The Fish and Crabs indicator group recorded a slight decline in score, from 0.71 in 2025 to 0.64 in 2026, but retained an overall Satisfactory (C) grade. Scores for Fish health remained high (0.87) reflected by Very Good (A) grade, while Fish recruitment declined in scores from 0.70 to 0.58, and downgraded to a Satisfactory (C) grade. Mud crab condition remained consistent, with a similar score and Satisfactory (C) grade to 2025.

Table 3.42 | Environmental indicator group scores used in the 2026 Gladstone Harbour Report Card.

Zone	Water and Sediment Quality	Habitats	Fish and Crabs
1. The Narrows	0.82	0.77	0.66
2. Graham Creek	0.88	0.73	0.61
3. Western Basin	0.85	0.74	0.87
4. Boat Creek	0.79	0.65	0.75
5. Inner Harbour	0.90	0.59	0.53
6. Calliope Estuary	0.89	0.73	0.68
7. Auckland Inlet	0.81	0.47	0.59
8. Mid Harbour	0.90	0.45	0.73
9. South Trees Inlet	0.87	0.71	0.66
10. Boyne Estuary	0.82	0.66	0.84
11. Outer Harbour	0.95	0.36	0.87
12. Colosseum Inlet	0.94	0.64	0.66
13. Rodds Bay	0.93	0.82	0.70
Harbour score	0.87	0.52	0.65

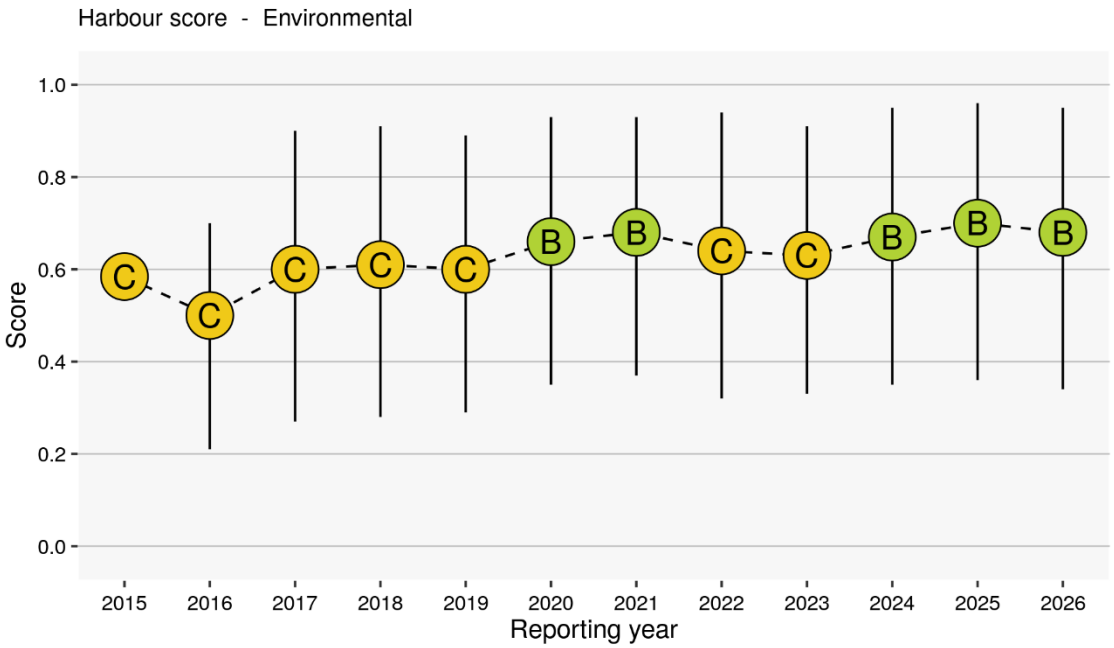

Figure 3.31 | Trends in Environmental Health scores 2015–26 (Error bars show 95% bootstrap confidence intervals).

4 Social

The Gladstone Harbour Report Card also reports on the social, cultural and economic condition of the harbour. In 2026, no new assessment was conducted for the Social component and results have carried over from the 2022 report card.

4.1 Data collection

The GHHP Independent Science Panel suggested a series of candidate indicators to assess the social aspect of harbour health in 2014 (McIntosh et al., 2014). The appropriate measures to evaluate these candidate indicators were identified by the GHHP Independent Science Panel and through a workshop with experts in social science and economics (Pascoe et al., 2014). 'Appropriateness' was based on a measure's relationship with the indicator, indicator group and its measurability. Eight indicators aggregated into three indicator groups (Harbour Usability, Harbour Access, and Liveability and Wellbeing) were used to assess the Social Health of the harbour (Table 4.1). These indicators were developed from the GHHP vision and piloted in 2014 (Pascoe et al., 2014).

A Computer Assisted Telephone Interview (CATI) survey of residents from the Gladstone 4680 postcode area was conducted in June 2022. Participants were contacted using a random dialling technique to mobile phone numbers. Note that the CATI survey was administered via different avenues across years; with 2014–16 via landline only, 2017–18 via landline and mobile numbers, and 2019 and 2022 via landline, mobile numbers, and internet survey. Trained research interviewers administered the survey, which had been thoroughly monitored for data QA/QC. The survey questions were largely qualitative and related to the GHHP social, cultural (*Sense of Place*) and economic objectives. All questions were designed to be answered on a 10-point agree-disagree scale. In the CATI survey, each participant was asked a specific question to suggest the first three words that come to their mind when thinking about Gladstone Harbour.

The marine safety incidents and oil spills measures in the Social component were not assessed through the CATI survey and instead a secondary dataset was used with a 10-year moving average as the baseline for comparison. The questions and 10-point scale were designed so that the results would be comparable to other studies (e.g. Social and Economic Long-Term Monitoring Program for the Great Barrier Reef) and to elicit trends over time (Pascoe et al., 2014).

Table 4.1 | The indicator groups, indicators and measures used to determine Social Health scores for the Gladstone Harbour Report Card (Adapted from De Valck, 2022).

Indicator Groups	Indicators	Measures	Data Source	Baseline data
Harbour Usability	Satisfaction with harbour recreational activities	How satisfied with last trip	CATI Survey (avg: Questions: Q11b, Q12b1, Q15b, Q25)	10-point scale
		Quality of ramps and facilities	CATI Survey (avg: Q28, Q28a)	10-point scale
	Air and water quality	Water quality satisfaction	CATI Survey (Q40)	10-point scale
		Air quality satisfaction	CATI Survey (Q41)	10-point scale
		Water quality does not affect use of the harbour	CATI Survey (Q42)	10-point scale
	Harbour safety	Marine safety incidents	Marine incidents in Queensland 2020 Department of Transport and Main Roads, Maritime Safety Queensland	Data 2011-2020 (calendar year). Rate of incidents in Gladstone maritime region compared to other Qld regions
		Oil spills	Queensland Department Transport and Main Roads, Maritime Safety Queensland Branch, 2019-2020 and 2020-2021	Data 2011-2020 (calendar year). Rate of incidents in Gladstone maritime region compared to other Qld regions
		Safe at night	CATI Survey (Q44)	10-point scale
		Happy to eat seafood	CATI Survey (Q43)	10-point scale
Harbour Access	Satisfaction with access to the harbour	Fair access to harbour	CATI Survey (Q29)	10-point scale
	Satisfaction with ramps and public spaces	Frequency of use	CATI Survey (Q8)	10-point scale
		Number of ramps	CATI Survey (Q27)	10-point scale
		Access to public spaces	CATI Survey (Q26)	10-point scale
	Perceptions of harbour health	Great condition	CATI Survey (Q33)	10-point scale
		Optimistic about future health	CATI Survey (Q34)	10-point scale
		Improved over the last 12 months	CATI Survey (Q35)	10-point scale
	Barriers to access	Marine debris a problem	CATI Survey (Q36)	10-point scale
		Marine debris affects access	CATI Survey (Q37)	10-point scale
		Shipping reduced use	CATI Survey (Q31)	10-point scale
		Recreational boats reduced use	CATI Survey (Q32)	10-point scale
Liveability and Wellbeing	Contribution of harbour to liveability and wellbeing	Makes living in Gladstone a better experience	CATI Survey (Q45)	10-point scale
		Participate in community events	CATI Survey (Q46)	10-point scale
		Aesthetic value	CATI Survey (Q45a, Q45b))	10-point scale

4.2 Development of indicators and scoring

Although the Social indicator questions used in the CATI survey were qualitative, they were recorded on a 10-point agree-disagree scale and the average satisfaction rating has been used in the analysis. Scores of 9 or 10 indicated very strong agreement; scores of 1 or 2 indicated very strong disagreement. A response of 9 or 10 provided a grade of A, a response of 7 or 8 provided a grade of B, 5 or 6 provided a C, 3 or 4 provided a D, and 1 or 2 provided an E. The report card scores are derived from a distribution of responses (weighted average) across the A to E grades thus differ from the mean scores that are reported in the results from the CATI survey.

Each measure was also weighted to reflect its relative importance as a management objective using information collected through an online survey of 83 community participants, 31 management experts (those with a management or industry role) and 19 technical experts (marine or coastal-social scientists). As such, the combination of the measures for each indicator reflects the final grade and not the simple average of the measure scores. Three weighting techniques – simple ranking methods, scoring-based methods and analytic hierarchy processes – were trialled in 2014 and a scoring-based method was used for weighting as it had the lowest variance (Pascoe et al., 2014).

A Bayesian Belief Network (BBN) was used to aggregate measures into indicator scores, indicator groups and component. This BBN model provided the probabilities of each outcome rather than a deterministic outcome. From the conditional probability distributions, an expected mean outcome and confidence interval were determined. The final grade for each indicator was the most probable grade after the relevant weights have been applied (Pascoe et al., 2014).

What is a CATI survey?



CATI is the abbreviation used for Computer Assisted Telephone Interview, a popular qualitative and quantitative data collection technique in social science and economics. Before the interview begins, all survey questions are entered into a special computer software. The data collection begins when the interviewer randomly dials a person's landline or mobile in the chosen geographic area for the study. If the participants agrees, the interviewer then starts reading out each question prompted by the software and records responses using a computer keyboard. The software used for the data collection is also programmed to show questions in a planned order and skipped questions, and allow randomization of questions schedule re-dialling, automate record keeping and most importantly send data directly to statistical software for data analysis. Australian Bureau of Statistics and Queensland Government Statisticians Office often use CATI as their primary method of data collection in various annual surveys.

4.2.1 Harbour Usability

Community satisfaction with Harbour Usability was primarily assessed through the CATI survey. The Harbour Usability indicator group comprised three indicators: satisfaction with harbour recreational activities, perceptions of air quality and water quality (in the harbour area), and perceptions of harbour safety for human use. The harbour usability survey questions related to participants' satisfaction with their last trip to the harbour, quality of boat ramps and facilities, satisfaction with air and water quality, safety at night, and whether people were happy to eat seafood from the harbour. There were eleven harbour usability-related survey questions in total. Secondary data on marine pollution and marine safety incidents were also incorporated into the harbour safety indicator as measures. A ten-year moving average was used as the baseline for both marine safety incidents and oil spill measures.

There have been minor changes in the marine incidents and oil spill data since 2014. The marine safety incidents measure in 2014 and 2015 were estimated using the ratios of incidents, with both recreational and commercial vessels registered within each maritime region. However, in 2016 due

to new regulations relevant to jurisdictional changes, Queensland reporting included only details of Queensland-regulated ships (99.8% recreational vessels) and not commercial vessels. Therefore, rates of oil spills and incident rates were available for recreational vessels only, and commercial vessel counts were not included in the assessment. This method was repeated in 2022 so that scores from 2016 continue to be comparable. The rate has been calculated as per 10,000 Queensland-regulated ships.

4.2.2 Harbour Access

The Harbour Access indicator group comprised four indicators: satisfaction with access to the harbour, satisfaction with boat ramps and public spaces, perceptions of harbour health, and perceptions of barriers to access. There were 11 harbour access survey questions such as perceptions on frequency of harbour use, number of boat ramps, access to public spaces, shipping and recreational boating, participants' perceptions on the state of the harbour health, and satisfaction with fair access to the harbour.

4.2.3 Liveability and Wellbeing

The indicator for the harbour's contribution to Liveability and Wellbeing in Gladstone was assessed using four questions in the CATI survey. The Liveability and Wellbeing survey questions related to whether Gladstone Harbour makes living in Gladstone a better experience, the level of participation in community events, and the aesthetic value of Gladstone Harbour to residents.

The aesthetic value measure was added to the Liveability and Wellbeing indicator group in 2018. Previous word cloud analysis highlighted the importance of the 'aesthetic aspect' of the harbour to Gladstone residents although there was no related measure in the indicator framework until that point. The addition of the aesthetic value measure complemented the Liveability and Wellbeing indicator group. By adding this measure, it was expected that the score of the indicator group would slightly improve compared to previous years, as aesthetic value is likely to attract a high score. This means the score for the indicator group is not fully comparable with previous years.

4.3 Social results

No new assessment was undertaken this year, so results from the 2022 assessment have been used to calculate the Social Health results for the 2026 report card (Table 4.2). A total of 200 respondents participated in the 2022 CATI survey. A 'snapshot' impression of the harbour was captured from the community survey respondents when they were asked to provide three words to describe the harbour. As in previous years 'Beautiful' and 'Fishing' were the two most used words, followed by words evoking the industrial nature of the harbour ('Busy', 'Industry', 'Industrial').

The overall score for the Social Health was 0.68, which was comparable with the score received when the Social Health was previously assessed (2019: 0.67). Both scores correspond to a good grade (B). Although scores have been similar since 2016, the overall Social Health of Gladstone Harbour has shown a strong improvement since the 2014 Pilot Report Card (0.58).

Of the three indicator groups, Harbour Usability received a score of 0.62, Harbour Access a score of 0.68 and Liveability and Wellbeing a score of 0.71 (Table 4.2). All three indicator group scores were comparable ($\pm$0.02) with the scores received in 2019.

Table 4.2 | Social Health indicator group and indicator scores used in the 2026 Gladstone Harbour Report Card. Scores from previous assessments are included for comparison.

Indicator groups	Social indicators	2026*	2026*	*2019*	*2018*
Harbour Usability	Satisfaction with harbour recreational activities	0.73	0.62	*0.64*	*0.63*
	Perceptions of air and water quality	0.59			
	Perceptions of harbour safety for human use	0.55			
Harbour Access	Satisfaction with access to the harbour	0.75	0.68	*0.67*	*0.67*
	Satisfaction with boat ramps and public spaces	0.67			
	Perceptions of harbour health	0.63			
	Perceptions of barriers to access	0.69			
Liveability and Wellbeing	Liveability and wellbeing	0.71	0.71	*0.70*	*0.70*
Overall score			0.68	*0.67*	*0.67*

*Results have carried over from the 2022 assessment

4.3.1 Harbour Usability

As in previous years, the 2022 assessment indicated most of the community viewed the harbour area as a place that provides recreational facilities and an enjoyable environment for leisure activities. The residents continued to see the harbour as a producer of healthy seafood and a safe place to enjoy by day and night (Table 4.3). Concerns remained about air and water pollutants, but these do not appear to impede the usability of the harbour area and its resources to the community. Air and water quality concerns may be an artefact of past issues and the proximity of industry in and around the harbour area.

The small decline in overall Harbour Usability score between the 2022 and 2019 assessments was due to a decline in people's perception of harbour safety for human use. Compared to 2019, the 2022 scores declined for oil spills (2019: 0.66, 2022: 0.38) and marine safety (2019: 0.54, 2022: 0.46). Over the 2018–20 period 1,360 new vessels were registered in Gladstone, with a new total of 49,115 vessels. The increased traffic may have contributed to the higher number of maritime incidents. It is also worth noting that many oil spill incidents reported in 2020 represent small amounts (in litres) whereas more pollution events in past years were reported in surface terms. As such, the reduction in oil spills score may be a data-entry artefact. Beyond these two measures, the other measures scored similar to the previous year.

4.3.2 Harbour Access

The 2022 Harbour Access results indicate that residents continue to enjoy the harbour, public spaces and boat ramps, and that perceptions of harbour health have not changed since 2019. Residents further agreed that they have fair access to the harbour compared to its other users, with increases in the recreational use of the harbour, boat ownership and use of boat ramps compared to 2018. Residents' perceptions around barriers to access has increased slightly since 2019. However, respondents continue to perceive that marine debris and litter is a problem in the harbour, although they did not see the levels of marine debris, commercial shipping and recreational boating activity as hindrances to harbour access. The harbour environment is viewed positively by many residents and they believe this will continue into the future.

4.3.3 Liveability and Wellbeing

Liveability refers to the elements in a region that affect how individuals feel about living there. These elements include the physical environment (natural and human) and social elements such as feelings of community spirit, personal health and wellbeing, culture and opportunities for work and recreation (Greer and Kabir, 2012). The Liveability and Wellbeing indicator score (0.71) was one point higher than the 2019 score (0.70) and seven points higher than the 2014 baseline (0.64).

Respondents are generally happy with the aesthetics of the harbour. However, many respondents state that they rarely participate in community events in the Gladstone Harbour area, indicating that improvements in community participation can still be made. Overall, the 2022 survey indicate that respondents enjoy going to the harbour because of its natural beauty.

4.4 Social trends

The overall Social health of the harbour has been gradually increasing since the pilot year, indicating that the Gladstone community continue to enjoy the harbour (Table 4.2 and 4.3). The overall score was one-point higher than in 2019 and was similar to that in 2016, 2017 and 2018 assessments. The Social component has received a Good (B) grade for the fifth consecutive year in which it was actively monitored (Figure 4.1). Note active monitoring was not completed between 2020–2021 and 2023–2026.

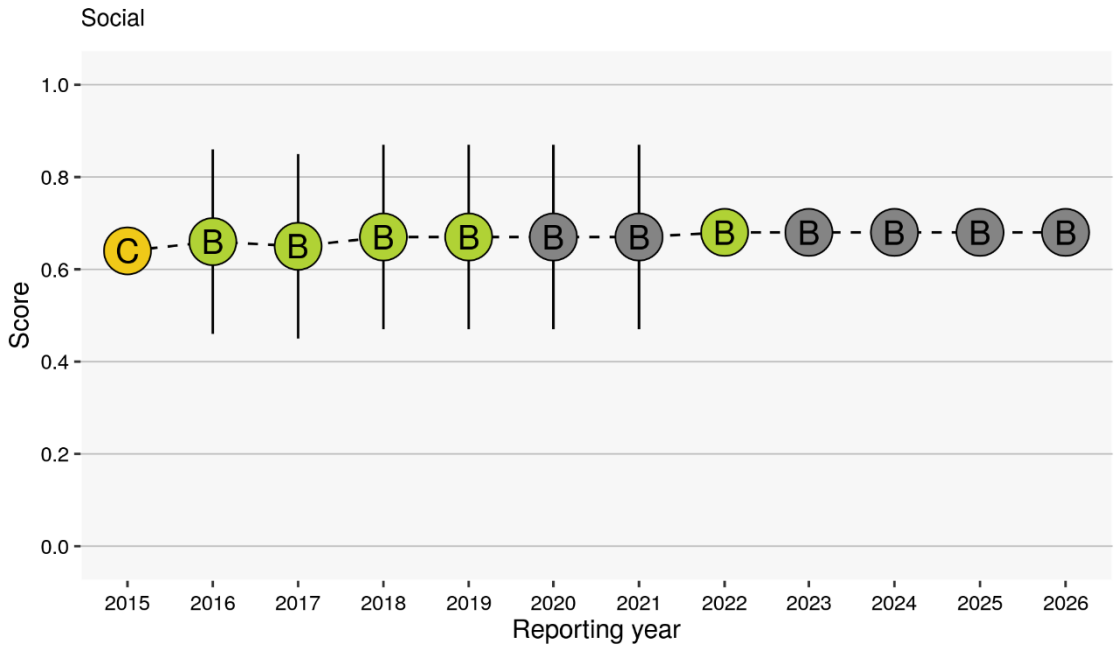

Figure 4.1 | Trends in Social Health scores from 2015–26 (Error bars show 95% bootstrap confidence intervals). Grey circles indicate years not assessed and results carried over from previous assessment.

Table 4.3 | Social Health scores compared between 2014, 2019 and 2022 assessments.

Group	Score	Indicators	2022	2019	2014	Measures	2022	2019	2014
Harbour Usability	2022: 0.62 2019: 0.64 2014: 0.60	Satisfaction with harbour recreational activities	0.73	0.71	0.70	How satisfied last recreational trip	0.76	0.74	0.74
						Quality of ramps and facilities	0.66	0.67	0.63
		Perceptions of air and water quality	0.59	0.58	0.46	Water quality satisfaction	0.60	0.58	0.39
						Air quality satisfaction	0.47	0.48	0.40
						Water quality does not affect harbour use	0.69	0.67	0.58
		Perceptions of harbour safety for human use	0.55	0.63	0.38	Marine safety incidents	0.46	0.54	0.24
						Oil spills	0.38	0.66	0.15
						Safety at night	0.69	0.62	0.58
						Happy to eat seafood	0.69	0.68	0.55
Harbour Access	2022: 0.68 2019: 0.67 2014: 0.61	Satisfaction with access to the harbour	0.75	0.73	0.67	Fair access to harbour	0.75	0.73	0.67
		Satisfaction with boat ramps + public spaces	0.67	0.65	0.60	Frequency of use	0.51	0.51	0.46
						Number of boat ramps	0.70	0.69	0.65
						Access to public spaces	0.77	0.74	0.68
		Perceptions of harbour health	0.63	0.63	0.53	Great condition	0.68	0.68	0.54
						Optimistic about future health	0.62	0.63	0.56
						Improved over the last 12 months	0.60	0.59	0.50
		Perceptions of barriers to access (Note: scores are reversed. A higher score denotes a decrease in the barrier)	0.69	0.66	0.64	Marine debris a problem	0.51	0.48	0.51
						Marine debris affects access	0.74	0.72	0.70
						Shipping reduced my use	0.74	0.69	0.63
						Recreation boats reduced my use	0.74	0.72	0.69
Liveability and Wellbeing	2022: 0.71 2019: 0.70 2014: 0.64	Liveability and wellbeing	0.71	0.70	0.64	Makes living in Gladstone a better experience	0.78	0.76	0.71
						Participate in community events	0.55	0.56	0.53
						Aesthetic value	0.76	0.73	n/a

5 Cultural

The Cultural health of the harbour is an evaluation of six Sense of Place indicators. In 2026, no new Cultural assessments were undertaken and results have carried over from the 2022 report card.

In 2024, the Independent Science Panel recommended the establishment of a new, Traditional Owner-led framework to replace the values assessed under the Cultural component of the Report Card. The new framework shifts focus from the use of detailed quantifiable archaeological assessments, moving the Traditional Owner Values out of the Cultural framework to an independent element of the Report Card itself (Maclean, 2025).

5.1 Data collection

The CATI survey conducted in June 2022 to assess Social Health also collected data for the Sense of Place indicator. That survey included 17 questions dedicated to gathering community views on six Cultural indicators (Table 5.1). Sense of Place was employed as a broad construct and it is assumed to incorporate elements of both place identity and place attachment (Twigger-Ross and Uzzell, 1996). Sense of Place may also be useful for exploring community stewardship.

The Indigenous Cultural Heritage scores for the report card are based on three physical condition measures assessed at site level and six management strategies measures assessed at the zone level. In 2025, the new Traditional Owner Values component is an independent element of the Gladstone Harbour Report Card, reported in Section 7.

Table 5.1 | Indicator groups, indicators and measures used to determine Cultural scores.

Group	Indicators	Measures	Data source	Baseline data
Sense of Place	Place attachment	No place better	CATI survey (Q30)	10-point scale
		Who I am	CATI survey (Q51)	10-point scale
	Continuity	How long lived in the area	CATI survey (Q3)	10-point scale
		Stay in area five years?	CATI survey (Q53)	10-point scale
	Pride in the region	Proud living in the area	CATI survey (Q50)	10-point scale
	Well-being	Quality of life	CATI survey (Q52)	10-point scale
		Input into management	CATI survey (Q47)	10-point scale
	Appreciation of the Harbour	Key part of the community	CATI survey (Q54)	10-point scale
		Great asset to the region	CATI survey (Q58)	10-point scale
		Great asset to Queensland	CATI survey (Q59)	10-point scale
	Values	Variety of marine life	CATI survey (Q55)	10-point scale
		Opportunities for outdoor recreation	CATI survey (Q56)	10-point scale
		Affects visitors to the region	CATI survey (Q57)	10-point scale
		Enjoy scenery and sights	CATI survey (Q60)	10-point scale
		Spiritually special places	CATI survey (Q61)	10-point scale
		Culturally special places	CATI survey (Q62)	10-point scale
		Historical significance	CATI survey (Q63)	10-point scale

Definition of indicators

- **Place attachment** is the degree to which the harbour provides an identity that is unique or distinct from other identities. This includes the distinctiveness of a place (e.g. coastal views, industry landmarks), the qualities which distinguish it from any other place (e.g. iconic marine species such as dolphins and dugongs), structure (the mental representation of a place) and meaning (subjective feelings linked to physically separate places).
- **Continuity** adds a temporal aspect to *Sense of Place*. It is the extent to which there has been continuity of 'self' (including ancestors) and activities in a place. It also includes both continuity in the way harbour resources have been used by past and present generations of a family as well as the ancestral links to places held by Indigenous Australians.
- **Pride in the region** concerns people's values and standards and assesses pride in one's identity in relation to place. It reflects the pride that an individual has in identifying with the place (Gladstone) and assesses the value and importance they assign to this association.
- **Well-being** relates to the extent to which a place facilitates or enables one's chosen lifestyle, or conversely, the extent to which a place does not hinder one's social and economic opportunities. This indicator assesses the sense of 'feeling at home' and the extent to which this provides spiritual fulfillment or is restorative.
- **Appreciation of the harbour** assesses the attitudes of people in Gladstone with particular emphasis on its importance as a great asset to the local community and Central Queensland.
- **Values** assesses community values on marine life, recreational and tourism activities, and the cultural, spiritual and historical significance of the harbour.

5.2 Development of indicators and scoring

Responses to cultural indicator questions in the CATI survey were converted to grades in the same manner as for the Social Health component. Thus, a response of 9 or 10 on a 10-point agree–disagree scale provided a grade of A, a response of 7 or 8 provided a grade of B, 5 or 6 provided a C, 3 or 4 provided a D, and 1 or 2 provided an E. As for the social indicators, each *Sense of Place* indicator was given a weighting that was developed during the pilot phase in 2014 via online surveys (Pascoe et al., 2014). A BBN aggregated measure scores into indicators and then to the *Sense of Place* indicator.

5.3 Cultural results and discussion

The Cultural component of the 2026 Gladstone Harbour Report Card received a score of 0.68 and a Good (B) grade. These results have been carried over from the previous assessment conducted in 2022.

In 2026, a single indicator, Sense of Place, contributed to the Cultural component. The result for Sense of Place suggests that the community's expectations of Gladstone Harbour area are mostly being met. Place attachment was slightly higher than previous years (Table 5.2), suggesting an increased engagement with and appreciation of the harbour. The continuity score (0.65) also improved compared to the previous year's receiving a Good (B) grade for the first time. This indicator measures the length of time people have lived in the area and whether they planned to stay for the next five years and the improvement of scores trend may suggest that the community is becoming less transient and more stable. The pride in the region score (0.76) has also remained stable indicating that residents continue to feel proud living in the Gladstone community. Wellbeing was one of the lowest scoring indicators (0.62) of the Sense of Place group and may suggest the community's view on quality of life is being met. The score for appreciation of the harbour remains the highest scoring indicator (0.84) and this has remained stable since 2014. This shows that residents continue to have a positive outlook for the harbour area and what it provides to the community. The values indicator scores (0.68) have also been stable across assessments. The scores and stability suggest that residents of the Gladstone region continue to value the harbour area because it supports a variety of marine life, provides opportunities for outdoor recreation,

attracts visitors to the region and is aesthetically appealing. However, fewer residents valued Gladstone Harbour highly based on its spiritual, cultural and historical significance.

Table 5.2 | *Sense of Place* indicator and indicator group scores used in the 2026 Gladstone Harbour Report Card. Scores from previous assessments are shown for comparison.

Indicator group	Indicators	2026*	2026*	*2019*	*2018*
Sense of Place	Place attachment	0.61	0.68	*0.66*	*0.65*
	Continuity	0.65			
	Pride in the region	0.76			
	Wellbeing	0.62			
	Appreciation of the harbour	0.84			
	Values	0.68			

*Results have carried over from the 2022 assessment

5.4 Cultural trends

The Cultural component was updated in 2025 and the new results scored 0.68 and Good (B) grade, although these are based on the results of the 2022 assessment (Figure 5.1 and Table 5.3).

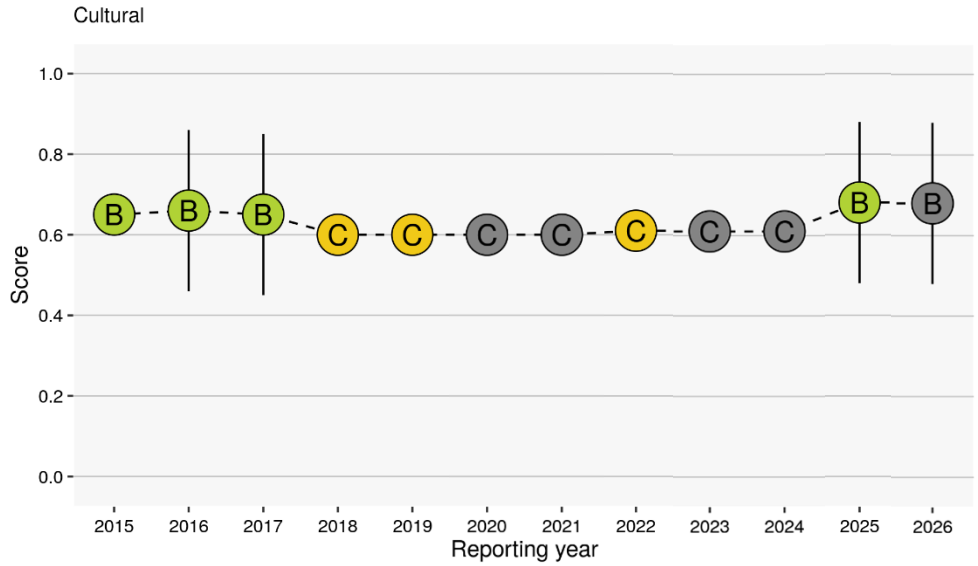

Figure 5.1 | Trends in Cultural scores 2015–26. Grey colour indicates no new monitoring; results have carried over from the previous year. Error bars show 95% bootstrap confidence intervals.

Table 5.3 | Sense of Place scores compared between assessments 2014, 2019 and 2022.

Sense of Place overall score	Indicators	Score			Measures	Score		
		2022	2019	2014		2022	2019	2014
2022: 0.68 2019: 0.66 2014: 0.64	Place attachment	0.61	0.58	0.55	No place better	0.56	0.51	0.49
					Who I am	0.65	0.64	0.61
	Continuity	0.65	0.58	0.57	How long lived in area	0.55	0.44	0.46
					Plan to stay the next 5 years	0.76	0.71	0.68
	Pride in the region	0.76	0.74	0.69	Feel proud living in Gladstone	0.76	0.74	0.69
	Well-being	0.62	0.61	0.55	Quality of life	0.69	0.69	0.64
					Input into management	0.55	0.54	0.46
	Appreciation of the harbour	0.84	0.83	0.80	Key part of community	0.82	0.82	0.79
					Great asset to region	0.83	0.82	0.79
					Great asset to Queensland	0.83	0.81	0.81
	Values	0.68	0.66	0.64	Variety of marine life	0.72	0.73	0.64
					Opportunities for outdoor recreation	0.79	0.78	0.76
					Affects visitors to the region	0.74	0.73	0.67
					Enjoy scenery and sights	0.79	0.76	0.75
					Spiritually special places	0.54	0.50	0.52
					Culturally special places	0.55	0.51	0.50
					Historical significance	0.57	0.52	0.58

6 Economic

To assess the Economic health of Gladstone Harbour, this report card uses eight indicators aggregated into three indicator groups: Economic Performance, Economic Stimulus and Economic Value (recreation). These indicator groups were developed from the GHHP vision and piloted in 2014. For the 2026 report Card, new assessment was undertaken for Economic Performance and partial assessment was undertaken for Economic Stimulus. Economic Value scores were based on the 2022 results.

6.1 Data collection

The Gladstone Local Government Area (LGA) was used as the broader geographic area for collecting economic data (Figure 11.28). However, slightly different geographic boundaries within the broader Gladstone LGA were used for some primary and secondary data as described below.

- Shipping data: collected for the Port of Gladstone
- CATI survey: administered to residents within the Gladstone 4680 postcode area (Figure 10.28)
- Commercial fishing data: collected from the area within QFish S30 which includes Gladstone Harbour and the open coastal waters immediately adjacent to the harbour. Data collected from Grid O25 and R29 were also used in the analysis to control for spatial differences in catch across years (Figure 11.29).

In comparison to the measures developed for the Social Component of the report card, most economic measures were more quantitative and different approaches were required to calculate indicator scores (Table 6.1). These include the following measures:

- Capacity utilisation – capacity used as a proportion of the total capacity available.
- Revenue-based information – based on total revenue over a particular time period.
- Index of Economic Resources (IER) – a weighted index based on income, housing expenditure and ownership, cost of living and household assets.
- Travel cost method (TCM) – assesses the value of a recreational activity from the expenditure made to participate in that activity, including travel costs, travel time and site costs.

Revenue-based information was used when the capacity utilisation method was too difficult or complex (e.g. for tourism and to some extent fisheries). Other economic data required to supplement the Economic Value of recreation and Economic Stimulus were collected through the CATI survey. A section of this survey was devoted to household economics, including questions related to income and home ownership. A section on the non-market Economic Values of recreation in the Gladstone Harbour area was also included. Scores for these values were determined using the TCM. Other data types were sourced from a range of organisations to derive other economic measures (Table 6.1).

Overall, the data collection and analytical techniques in 2026 remained the same as the 2019 reporting year for all economic indicators. To improve the quality of the indicator framework, minor modifications have been made since the pilot report card in 2014:

- Using 2021 national census data to calculate socio-economic status indicator (scores for this indicator were previously based on 2011 and 2016 census data).
- Removing the line fishing measure from the Commercial fishing indicator due to considerable data gaps in the database.
- Adding a new indicator ‘water-based recreation’ to the Economic Value (recreation) indicator group in 2018.

Table 6.1 | Data sources and baselines employed to derive the Economic Health scores for the 2026 Gladstone Harbour Report Card.

Group	Indicator	Measure	Data source	Baseline data
Economic Performance	Shipping activity	Shipping activity productivity calculated from monthly shipping movements by cargo type (2025–26 financial year)	GPC https://content3.gpcl.com.au/viewcontent/CargoComparisonsSelection/	10-year average (time series data from 2015–16 to 2025–26)
	Tourism expenditure	Gladstone region's total tourism expenditure output (ABS 2024/25 tourism satellite account)	Tourism Research Australia's information at the LGA level (Gladstone) https://app.remplan.com.au/gladstone/economy/tourism/output?state=B6JmCj!WAe3inVjpT3xXymU8R7nwHdibIKOkcmyMyOHv9A9klpI7zfIldhyx5vFJav	10-year average (time series data from 2014–15 to 2024–25)
	Commercial fishing	Productivity of net fisheries Productivity of trawl (otter) fisheries Productivity of pot fisheries	Production (fishing effort) Queensland Fishing (QFish), Queensland Department of Agriculture and Fisheries Prices (fish, prawns & crabs) Australian Bureau of Agricultural and Resource Economics and Sciences – Australian fisheries and aquaculture statistics 2020 (published Aug 2021)	10-year average (time series data from 2015–16 to 2025–26)
Economic Stimulus	Employment	Gladstone LGA unemployment data (2024 March quarter)	Australian Department of Employment, *Small Area Labour Markets*	Queensland 2021 distribution (Dec quarter)
	Socio-economic status	Index of economic resources derived from 2016 ABS census and updated using the community CATI survey	2022 CATI survey; Australian Bureau of Statistics, 2016 census	Australian 2016 distribution
Economic Value (recreation)	Land-based recreation	Land-based recreation satisfaction + economic value	Satisfaction: CATI survey + economic value (Pascoe et al., 2014)	10-point scale
	Recreational fishing	Recreational fishing satisfaction + economic value	Satisfaction: CATI survey + 2018 updated economic value (Cannard et al., 2015; Windle et al., 2018)	10-point scale
	Beach recreation	Beach recreation satisfaction + economic value	Satisfaction: CATI survey + 2019 updated economic value	10-point scale
	Water-based recreation	Water-based recreation satisfaction + economic value	Satisfaction: CATI survey + economic value (Windle et al., 2017)	10-point scale

6.2 Development of indicators and scoring

6.2.1 Economic Performance

The Economic Performance indicator group consists of three indicators: Shipping activity, Tourism (expenditure), and Commercial fishing. These were selected to reflect the key industries using the harbour and weighted according to relative contributions to revenue share across the three activities.

Shipping activity

The GPC provided data on monthly shipping movements by cargo type, destination and origin. The report card score for Shipping activity was based on capacity utilisation (current level of activity relative to potential level of activity) and estimated through data envelopment analysis (DEA).

Time series data from 2012–13 to 2021–22 was used in the analysis. Prior to 2017, a 20-year array was used. The Shipping activity is weighted higher than the other two sectors due to its greater contribution to the economy in Gladstone.

Tourism expenditure

The Tourism score is based on the expenditure on hotel accommodation, food and other local services relative to a 10-year average from 2009–19 in the Gladstone Region. This information is sourced from Tourism Research Australia's information at the LGA level (Gladstone):

www.tra.gov.au/en/profiles/local-government-area-profiles

Commercial fishing

The indicator score for Commerical fishing was based on production (fishing effort based on number of licences and number of days fished) and the value of the landed catch (in kg) in three sectors: the net (fish), pot (mud crab) and otter trawl (prawns) fisheries in Gladstone Harbour relative to a 10-year average starting from 2012. Production figures come from the three grids, but prices are Queensland state-wide estimates (Figure 11.29).

Capacity Utilisation

Capacity utilisation measures the productive efficiency (performance) of an industry for a given time period. It is often expressed as a percentage. Reasons for increased capacity utilisation include increased market demand and availability of new technology to increase production. Reasons for decreased capacity utilisation include seasonal variations, reduction in market demand, reduced production or, perversely, increased capacity.

For example: A factory produces cement. It has a maximum output of 10,000kg per month. During January the actual output was 5,000kg. So, what was the capacity utilisation in January? It can be calculated as a percentage using the following formula:

Capacity utilisation

$$= \frac{(actual\ level\ of\ output\ (5{,}000)}{(maximum\ possible\ output\ (10{,}000))} \times 100$$

= 50%

Data Envelopment Analysis (DEA)

The DEA or frontier analysis is a tool developed in 1978 by Charnes, Cooper and Rhodes as a technique to measure the performance or relative efficiency of organisations such as banks, hospitals and schools. During the analysis, a reference is set, including the best- performing organisations, which is called and 'efficiency frontier'. The efficiency frontier acts as the threshold for assessing the performance of other organisations. The organisations in the frontier are considered 100% efficient and the others within the efficiency frontier are considered less than 100% efficient. This analysis is very important when we need to compare organisations with multiple inputs and outputs and need a special software tool to calculate the efficiency scores. The DEA analysis is performed on the capacity utilisation measures in two of the report card indicators: shipping and commercial fishing.

Index of Economic Resources (IER)

The IER is a composite measure of the economic wellbeing of a community. For the 2019 Gladstone Harbour Report Card this was calculated using census data collected by the ABS. The index focuses on census variables such as the income, housing expenditure and ownership, cost of living, and assets of households. The variables used in the index are also weighted by the ABS. This index does not consider educational and occupation variables as these are not direct measures of economic resources.

Commercial fishers operating in Queensland's state-managed fisheries are required to complete daily catch and effort logbooks. These logbooks enable fishers to record approximately where, when and how fishing took place, and what was caught. Catch-and-effort data are available from the QFish database maintained by Queensland Department of Primary Industries. Those data are recorded from 30 x 30 nautical mile grids and therefore provide only a very general indication of the location of fishing activity. Fishing production data collected from Grid S30 was used as the primary data source for the Commercial fishing indicator. This covers most of the Gladstone Harbour and open coastal waters immediately adjacent to the harbour (Figure 11.29).

The total value of Commercial fishing was estimated based on catch data by fishing method data from the QFish database and average prices for each species group (fish, prawns and crabs) was derived from the most recent Australian fisheries and aquaculture statistics published by Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) statistics in 2020. The total value of fisheries production in Mackay (Grid O25) and Yeppoon (Grid R29) was also included in the analysis to control for spatial differences in catch across years as they provided more balanced information on fishing productivity in the region, and to control for fish mobility (Windle et al., 2018).

A capacity utilisation approach is applied, and the measures of relative productivity were estimated using the DEA. The three fisheries sector scores were weighted by their relative contribution to gross value of production.

6.2.2 Economic Stimulus

The Economic Stimulus indicator group consists of two indicators: Employment and Socio-economic status.

Employment

The score for employment was based on the unemployment rate for the Gladstone LGA compared with the benchmark of the Queensland unemployment rate. This comparison used the most recent Australian Bureau of Statistics data available which were for the 2026 March quarter.

Socio-economic status

The score for Socio-economic status was derived using the IER which is a composite measure of the economic wellbeing of a community. It takes into account 14 variables including income extremes (both high and low) in a population, household ownership, cost of living and other indicators relevant to economic wellbeing in the community. The IER was calculated using 2016 Australian census data. A system of weightings for the variables and estimates for the Gladstone Region were further refined using data collected through the CATI survey. The IER for Gladstone is compared with the IER for other LGAs in Australia to generate a report card score.

6.2.3 Economic Value (recreation)

The Economic Value (recreation) indicator group was assessed through four indicators: Land-based recreation, Recreational fishing, Beach-based recreation and Water-based recreation (non-fishing). The Water-based recreation indicator was added to the Economic Component in 2018 and based on the estimated trip value.

Two elements of the recreational values can be assessed:

- The commercial value of the recreation and tourism (estimated based on financial records of commercial tourist operators).
- The non-market value (value associated with residents who use the harbour for recreation but their activity is not reflected in financial records of commercial providers).

While the former is already captured in the Economic Performance indicator, the latter is included in the Economic Value (recreation) indicator group.

The scores for the four indicators in the Economic Value (recreation) indicator group are based on the satisfaction ratings for each recreation activity type and the non-market economic value of the recreation activity type.

Information on the non-market Economic Value (recreation) of harbour area activities was collected through a community survey of 200 people within the Gladstone Region via the CATI survey. Data on travel costs, travel time, and other access and site costs were used in the TCM to calculate the economic value of using a recreational site based on the investment that people have made. In 2014, the economic value of land-based ($61 per trip) and beach-based recreational trips ($40 per trip) were estimated (Pascoe et al., 2014). Additional information was collected in 2015 and 2017 to estimate the value of a recreational fishing trip ($141) and water-based recreation ($95) (Cannard et al., 2015; Windle et al., 2017). The per-trip recreational values will be updated every five years.

TRAVEL COST METHOD (TCM)

Travel cost method is an important economic non market-evaluation technique developed by Clawson (1959). It assesses the monetary value of natural resources used extensively for recreation (e.g. fishing, the beach) that cannot be evaluated through market prices. The key principle behind the TCM is that the cost of travel and time a person invests to visit a place can be used to assign a dollar value to the place and hence would be extremely useful in resource management.

The Economic Value assessment has been established in 2014 and 2015 and updated annually through the data (participation frequency rates) collected from the CATI survey. The user satisfaction information on the four types of recreational activities are also collected from the CATI survey.

The indicator scores for land-based recreation, recreation fishing, beach recreation and water-based recreation were determined by the satisfaction rating (from CATI survey) for each activity. These were then weighted by their relative contribution to the Economic Value of recreation (value of a recreation trip multiplied by the participation frequency rate).

6.3 Economic results and discussion

The Economic component achieved an overall score of 0.71, corresponding to a Good (B) grade, unchanged from 2025 (Table 6.2). Economic Performance remained strong, with a score of 0.85, supported by high tourism (0.90) and shipping activity (0.84) results. While shipping activity declined slightly from 0.89 in 2025, the port continued to be well utilised, indicating high levels of trade and shipping activity. Commercial fishing improved to 0.46, up from 0.19 in 2025, likely reflecting the inclusion of more complete and up-to-date fisheries data and providing a more representative assessment of commercial fishing activity in the region.

Economic Stimulus improved from 0.51 in 2025 to 0.59 in 2026, driven by stronger socio-economic status results (0.76), despite employment remaining low (0.36). Economic Value (recreation) maintained a score of 0.77, unchanged from previous assessments, highlighting the ongoing importance of recreational activities to the region. Scores for land-based recreation (0.79), recreational fishing (0.73), beach recreation (0.77) and water-based recreation (0.77) were carried forward from the 2022 assessment.

Table 6.2 | Economic indicator and indicator group scores used in the 2026 Gladstone Harbour Report Card.

Indicator group	Indicators	2026	2026	*2025*	*2024*
Economic Performance	Shipping activity	0.84	0.85	*0.89*	*0.90*
	Tourism	0.90			
	Commercial fishing	0.46			
Economic Stimulus	Employment	0.36	0.59	*0.51*	*0.50*
	Socio-economic status	0.76			
Economic Value (recreation)	Land-based recreation^	0.79	0.77	*0.77*	*0.77*
	Recreational fishing^	0.73			
	Beach recreation^	0.77			
	Water-based recreation^	0.77			
Overall score			0.73	*0.71*	*0.74*

^No assessment was undertaken in 2026; results carried over from 2022.

6.4 Economic Trends

The overall grade for the Economic component of the Gladstone Harbour report card remains Good (B) in 2026 and has been stable since the first full report card in 2015, with only a small fluctuation in scores (Figure 6.1 and Table 6.3). In contrast, the trends for the three indicator groups and the indicators have varied.

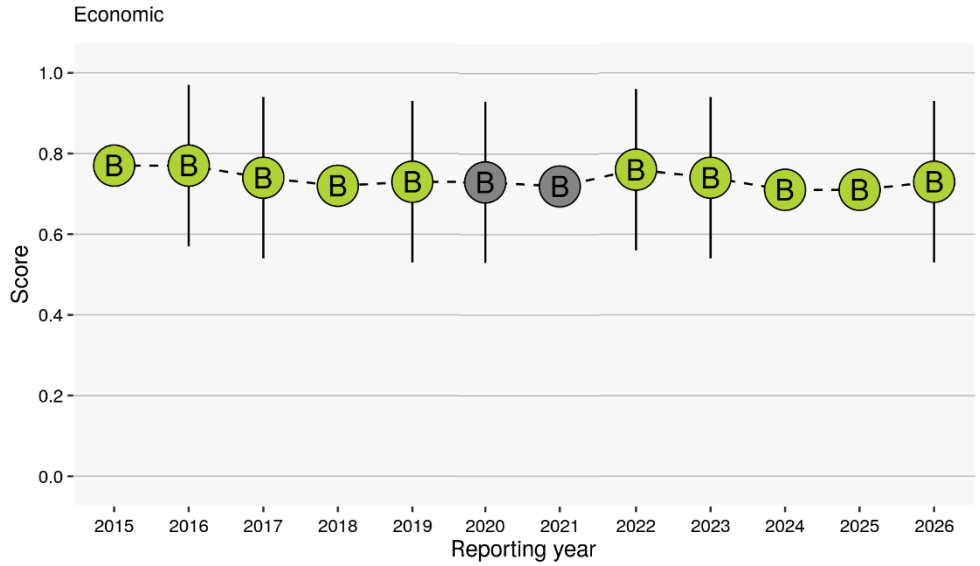

Figure 6.1 | Trends in Economic Health scores 2015–26. No new assessments were undertaken in 2020 or 2021 (grey circle) and results carried over from the previous year. Error bars show 95% bootstrap confidence intervals.

Since reporting began in 2015, Economic Performance consistently achieved the strongest results, maintaining a Very Good (A) grade since 2016. Economic Value (recreation) remained stable and positive, consistently receiving a Good (B) grade with a slight long-term improvement. In contrast, Economic Stimulus declined markedly from a Very Good (A) grade in 2014 to a Satisfactory (C) grade from 2018 onwards, although a modest recovery was observed in 2026 (Figure 6.2).

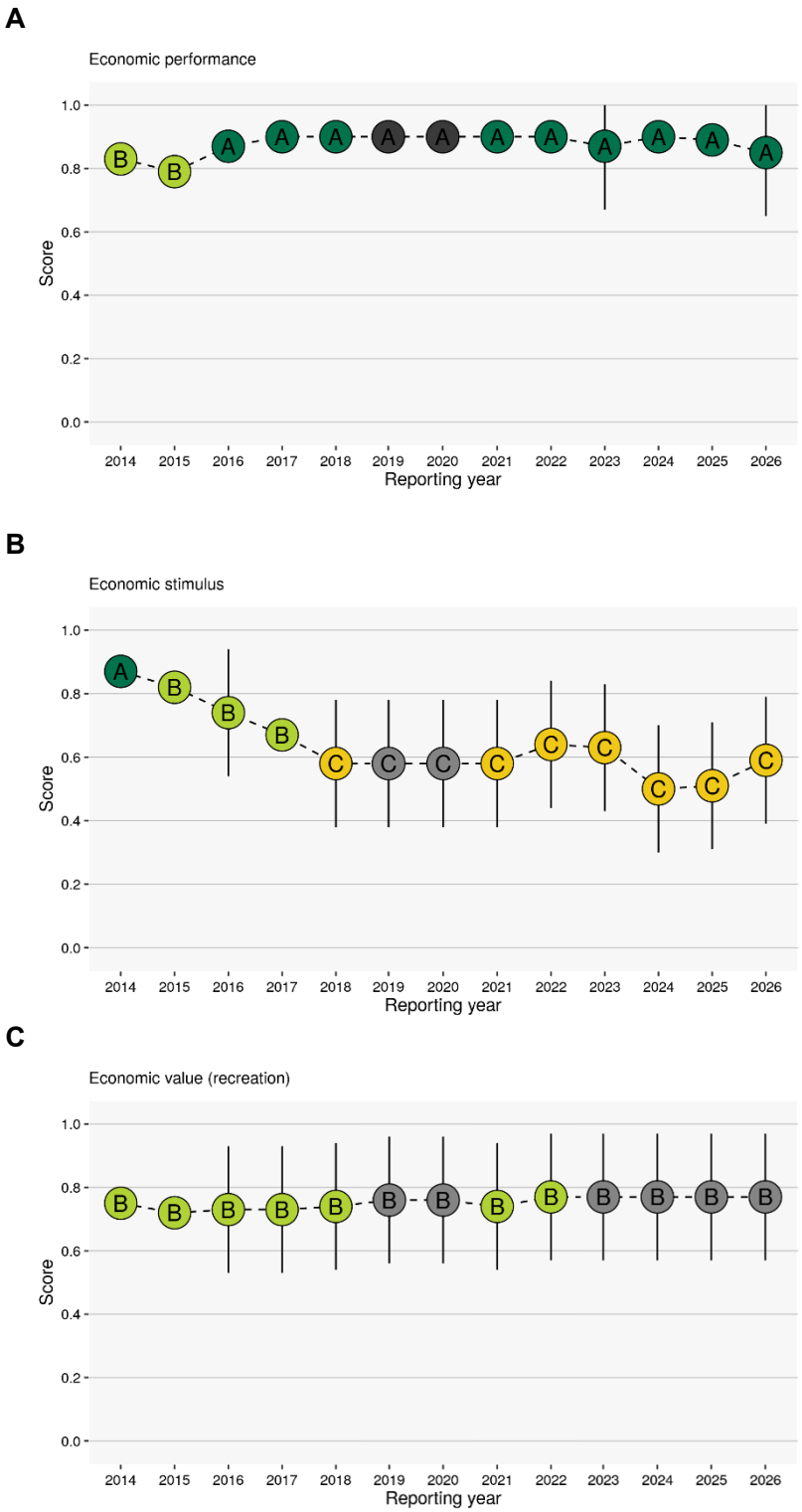

Figure 6.2 | Trends in Economic indicators **A** Economic Performance, **B** Economic Stimulus and **C** Economic Value (recreation) 2015–26. Grey circles represent no new assessment; results carried over from the previous year. Error bars show 95% bootstrap confidence intervals.

Table 6.3 | Economic Health scores compared between report cards 2014–26.

Economic Component 2026: 2025: 0.71 (B) | 2024: 0.71 (B) | 2023: 0.74 (B) | 2022: 0.76 (B) | 2019: 0.73 (B) | 2014: 0.75 (B)																		
Indicator group Score/grade	**Indicators**	**Score**							**Measures**	**Score**								
		2026	2025	2024	2023	2022	2019	2014		2026	2025	2024	2023	2022	2019	2014		
Economic Performance	Shipping activity	0.84	0.89	0.90	0.86	0.90	0.90	0.83	Shipping activity: productivity	0.84	0.89	0.90	0.86	0.90	0.90	0.83		
	Tourism	0.90	0.90	0.90	0.90	0.90	0.90	0.60	Tourism expenditure	0.90	0.90	0.90	0.90	0.90	0.90	0.60		
	Commercial fishing	0.46	0.34	0.34	0.37	0.41	0.36	0.66	Net fisheries: productivity	0.10	0.10	0.46	0.45	0.45	0.25	na		
									Trawl fisheries: productivity	0.27	0.10	0.10	0.24	0.31	0.29	na		
									Pot fisheries: productivity	0.90	0.38	0.55	0.52	0.55	0.64	na		
Economic Stimulus	Employment	0.36	0.20	0.19	0.43	0.45	0.44	0.72	Unemployment statistics for the Gladstone LGA		0.20	0.20	0.43	0.45	0.44	0.72		
	Socio-economic status	0.74	0.74	0.74	0.75	0.74	0.64	0.90	Index of economic resources	0.74	0.75	0.74	0.75	0.74	0.64	0.90		
Economic Value (recreation)	Land-based recreation	0.79*	0.79*	0.79*	0.79*	0.79	0.77	0.76	Satisfaction rating from CATI survey + value from 2014 survey	0.79*	0.79*	0.79*	0.79*	0.79	0.77	0.76		
	Recreational fishing	0.73*	0.73*	0.73*	0.73*	0.73	0.71	0.67	Satisfaction rating from CATI survey + value from 2015 survey	0.73*	0.73*	0.73*	0.73*	0.73	0.71	0.67		
	Beach recreation	0.77*	0.77*	0.77*	0.77*	0.77	0.76	0.71	Satisfaction rating from CATI survey + value from 2014 survey	0.77*	0.77*	0.77*	0.77*	0.77	0.76	0.71		
	Water-based recreation	0.77*	0.77*	0.77*	0.77*	0.77	0.76	na	Satisfaction rating from CATI survey + value from 2017 survey	0.77*	0.77*	0.77*	0.77*	0.77	0.76	na		

*No new assessment; results carried over from assessment.

7 Traditional Owner Values

7.1 Development workshop

In October 2024, GHHP, in collaboration with the First Nations Bailai, Gurang, Gooreng Gooreng and Taribelang Bunda Development Corporation (FNBGGGTBDC), hosted a two-day Traditional Owner Values Workshop aimed at reframing Indigenous cultural indicators in the Gladstone Harbour Report Card. The event marked a milestone in the evolution of the GHHP Report Card, aiming to reintroduce and redefine the role of Traditional Owner values in Harbour health reporting. An Indigenous Cultural Heritage indicator was first introduced into the Report Card in 2015, supported by a monitoring program across four cultural zones and 39 reference sites. While the data collected in 2015, 2017, and 2018 was robust, logistical challenges hindered ongoing assessments. In response to recommendations from the GHHP Independent Science Panel, the 2024 workshop sought to:

- Replace “Indigenous Cultural Heritage” within the Cultural component with a stand-alone “Traditional Owner Values” component
- Shift from archaeological metrics to holistic, qualitative indicators
- Establish a Traditional Owner-led framework
- Elevate Traditional Owner Values as an independent element of the GHHP Report Card

The workshop included visits to culturally significant locations such as Barney Point Park and Phillipies Landing Road, a site where erosion and other activities are impacting stone arrangements. These visits provided context for the discussions that followed.



Figure 7.1 Left: Inspecting an artefact during the site visits; Right: Workshopping ideas for a new Traditional Owner Values element of the GHHP Report Card.

The workshop explored foundational questions around what GHHP and FNBGGGTBDC would like to achieve, generating dialogue around the role of Elders, connection to Country, cultural site management, and community and stakeholder relationships. The participants also reviewed the work of other report cards in the space.

The workshop sessions generated a range of insights that helped shape the emerging Traditional Owner Values component. Participants emphasised the central role of Elders in cultural knowledge transfer and decision-making, alongside the importance of protecting and managing cultural sites, improving access to Country, and fostering education both within the community and among stakeholders. There was strong support for incorporating traditional language into signage and recognising the intangible and spiritual significance of Gladstone Harbour. New cultural reference sites were proposed, including Canoe Point, Curtis Island, and The Narrows quarry site. Participants recommended cultural mapping to demonstrate the connectivity of sites across the landscape. The idea of presenting Traditional Owner values through case studies was well received, with suggestions to include site condition, impacts, and management options, and to link sites to GHHP partners to encourage shared responsibility and education.

The participants proposed that key cultural sites be featured as case studies in future Report Cards to communicate both values and management needs. Continued cultural site assessments would be conducted, with the integration of drone and reality capture technology to support documentation and monitoring. The inclusion of a foreword from the Elders Council was suggested as a way of grounding the Traditional Owner Values component in cultural authority. The participants also expressed a desire to ensure that Traditional Owner perspectives are embedded in decision-making and that cultural heritage is respected and protected across the Gladstone region.

8 Litter indicator

8.1 Litter

Litter is included as a formal indicator in the 2026 Gladstone Harbour Report Card, but separately to the four components of harbour health (Environment, Social, Cultural and Economic).

The litter index is comprised of a single indicator to assess the “pressure” that the amount of litter and/or marine debris (from here on referred to as litter) present in a location may be having on that environment. The data used to derive the scores and grades for the litter index is from the Australian Marine Debris Initiative® (AMDI) database and is collected in the field by volunteers as part of the Tangaroa Blue Foundation® (TBF) clean-up projects and the ReefClean Project and its partners.

Technical expertise for the calculation of scores and grades was provided to this project by Dinny Taylor and Bill Venables. A model has been developed from ‘baseline’ data from the period ~2009 to June 2019 available from the AMDI for each of the partnership regions; Wet Tropics Waterways, Healthy Waters Partnership for the Dry Tropics, Healthy Rivers to Reef and GHHP. The litter collected at sites each year are then compared with this baseline to determine their score and grade.

As this metric is based on a dataset collected by volunteers, there is some inconsistency with sample sizes and sampling locations across zones and years. Scores and grades are therefore presented at the site level, rather than rolled up into a zone level score. This reduces biases on scores that would come with changes in sampling effort from year-to-year and will allow better representation and comparison of how the amount of litter has changed at particular sites across report cards.

The following methods are described as per that designed for the Dry Tropics Partnership for Healthy Waters Report Card (Whitehead, 2020) with filtering methods applied by UNSW as per Appendix 4. Note, different methods may have been applied to the other regional report cards.

GHHP acknowledges the AMDI®, TBF®, the community organisations, and individuals involved in the collection and the provision of data used in this report. This includes ReefClean which is funded by the Australian Government’s Reef Trust and delivered by Tangaroa Blue Foundation in partnership with Reef Check Australia, Capricornia Catchments, Eco Barge Clean Seas, OceanWatch Australia, South Cape York Catchments and Australian Microplastics Assessment Project.

8.2 Litter data collection

Forty-nine clean-ups were recorded in the AMDI Database in 2024-25 in the Gladstone region. These clean-ups were one of two types: standardised ‘ReefClean’ sampling and non-standardised clean-ups.

8.2.1 Standardised ‘ReefClean’ sampling

The ReefClean project began in early 2019 with funding from the Australian Government’s Reef Trust, led by the Tangaroa Blue Foundation and several partner organisations. Volunteers collected litter along measured transects for a designated length of time. Standardised clean-ups began in mid-2018 and will continue quarterly until June 2023. This standardised method enables comparisons across years. All debris were sorted into one of 127 categories and recorded in the AMDI Database. ReefClean data are incorporated into the litter metric where available.

8.2.2 Non-standardised clean-ups

Non-standardised clean-ups were also conducted across the Gladstone region, varying in location and frequency across years. Generally, easy-to-access and 'volunteer friendly' sites (such as popular beaches) are cleaned more frequently than other beaches. Non-standardised clean-ups have no defined boundary and while the number of participants and the total duration of the clean-up event is recorded, individual effort is not (leading to unequal effort of individuals across the duration of the event). All debris collected was sorted into the AMDI categories and entered into the database. Due to inconsistency in how rigorous the debris sorting and recording process was among volunteers, the litter could not be divided into individual categories, so litter was totalled into a 'total litter' category.

8.3 Development of litter indicators and scoring

Initial development of the litter indicator was completed by Bill Venables and Tegan Whitehead (Dry Tropics Partnership) and first incorporated in the Townsville Dry Tropics Report Card 2019. The current analysis was completed by Dinny Taylor from Healthy Waters Partnership Dry Tropics and involves a revision of the initial modelling.

The litter that is collected is sorted and recorded in a number of categories, but currently total litter is used in the analysis and scoring.

8.3.1 Establishing the baseline

Total litter collected at each site in the current reporting year is compared against a baseline derived from historical data collected across the five GBR report card areas from 2009 to June 2019 (data was only available at the GHHP sites from 1 July 2014). This baseline period was chosen to represent a time before many of the Queensland Government state-wide management restrictions were put in place (plastic bag ban from 1 July 2018 the container refund scheme from 1 November 2018 and the single use plastics ban from 1 September 2021).

During the baseline period to 30 June 2019, clean-ups occurred at 42 sites across 12 GHHP monitoring zones in the Gladstone region (Appendix 5). The frequency that each site was cleaned during this baseline period varied.

8.3.2 Litter index scoring

To calculate scores and grades for total rubbish, scores and grades for the 2022-23 reporting year were determined by relating annual data to a reference distribution (Taylor, 2024). Data were scaled from 0 to 1 for the report card, with close to zero equating to "near pristine" and close to 1 being a "highly littered" state.

In simplified terms, the process can be summarised as (Taylor, 2024):
Model Development

- Model the linear relationship between the parameters and fit to the model data
- Obtain estimates for each data point for an input of 1 hour of cleaning effort (to standardise the number of items)
- Obtain the model to transform the standardised Items to a standardised score and grade
- Calculate the mean score for each Site for each year (this is because some sites have more than one collection per year or 'Event')
- Convert the mean score to the grade based on the transformation model

Each Year of Data for Reporting

- Add the new year of data to the baseline dataset (this will provide the baseline dataset for the next year)
- Re-fit the linear relationship between the parameters for the updated dataset
- Obtain the estimates from the linear model for each datapoint for an input of 1 hour of cleaning effort (standardised number of items)
- Obtain the score for each collection Event using the transformation to score and grade model.
- Calculate the mean score for each Site for each year
- Convert the mean score to the grade using the transformation to score and grade model.

Zone scores and grades are not calculated as to do so would not be representative or comparable from year to year. This is because there is no consistency between the Sites that are included in each Zone.

Figure 8.1 shows the histogram as the proportional density for each of the regions included in the model:

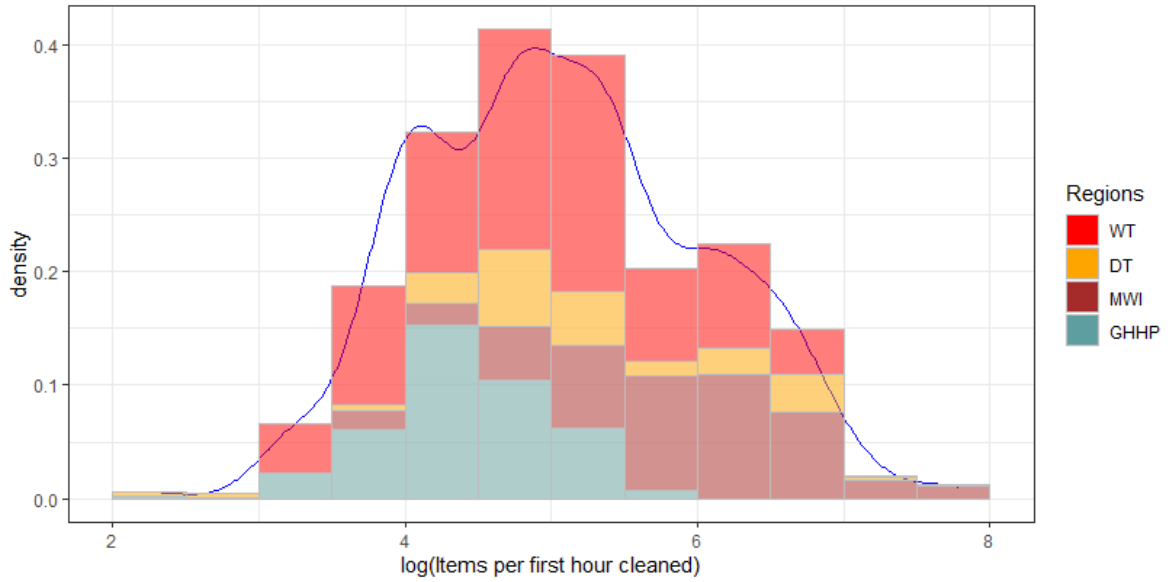

Figure 8.1 | Proportional histogram density plot of the Kernel Density Estimate for the baseline litter model. WT – Wet Tropics (Wet Tropics Waterways), DT – Dry Tropics – (Healthy Waters Partnership for the Dry Tropics), MWI – Mackay-Whitsunday-Isaac (Healthy Rivers to Reef), GHHP – Gladstone Harbour (Gladstone Healthy Harbour Partnership) and the Kernel Density Estimate (blue line curve) for the total data set. This shows that the largest proportion of the data is from the WT and MWI regions and the GHHP data has a smaller distribution range.

8.3.3 Note about scoring used for litter indicator

It is important to note that scoring for the litter indicator is different to the standard scoring system used by all other GHHP indicators (Table 8.1). This was to ensure consistency in the scoring system among other regional report cards such as Wet Tropics, Dry Tropics and Mackay-Whitsundays Isaac. Although the scoring system and thresholds are consistent between the four partnerships, it is not appropriate to directly compare grades/scores between regional report cards. This is because grades/scores for each report card are based on a four-year baseline which is unique to the dataset in their region. Thus, a 'moderate pressure' score for one partnership is not equal to a 'moderate pressure' score for another partnership. Comparability is only relevant in terms of site improvement or deterioration (e.g., the number of sites that showed less rubbish and thus had a better score than the previous year, and vice versa).

Table 8.1 | Scoring range guide to colours and textual context. Note that scoring range cut-offs are dependent on annual data distribution.

Colour	Context	Score range
	Very high pressure	0 to 5
	High pressure	>6 to 36
	Moderate pressure	>36 to 65
	Low pressure	>66 to 79
	Slight/Very low pressure	>80 to 100

8.4 Litter results

For interpreting litter results, it is notable that score cut-off points are based on annual data distribution (Figure 8.1) and refer to a scale of 'very high pressure' to 'slight pressure' (Table 8.1). Refer to Table 8.2 and Figure 8.2 for sites scores, with results summarised as:

Table 8.2 | Litter scores by site across the Gladstone region for the 2026 report Card using data collected between July 2024 and June 2025. Note that scoring range cut-offs are dependent on annual data distribution. 2024 recalculated scores are shown for comparison, with change in scores between collections also illustrated.

Zone	Site	2025	*2024*	*2023*	*2022*	*2021*	*2020*
5. Inner Harbour	Barney Point, Gladstone	49	77	75	77	81	78
	West Beach Quoin Island	84	–	–	–	–	–
6. Calliope Estuary	Auckland Creek, Hanson Road	48	68	66	42	88	56
	Spinnaker Park Parkland, Gladstone	90	–	–	–	84	–
8. Mid Harbour	Canoe Point, Tannum Sands	92	97	97	93	96	87
	East Beach, Quoin Island	95	74	73	93	–	98
	Lilley's Beach, Boyne Island	63	63	61	74	55	74
	Oaks Beach, Facing Island	97	–	–	–	–	–
	Main Beach, Tannum Sands	94	71	69	87	74	90
10. Boyne Estuary	Canoe Point Cons. Area, Tannum Sands	96	–	–	–	99	75
	Eastern Foreshore, Boyne River	41	92	91	69	78	73
11. Outer Harbour	East Shore Ocean Beach, Facing Island	28	–	–	–	–	–
	Joey Lees Beach, Curtis Island	21	91	93	54	13	47
	North Joey Lees, Curtis Island	38	–	–	–	–	–
	Stone Hut, Curtis Island	36	–	–	28	2	11
	Turtle Street Beach, Curtis Island	38	16	14	83	44	–

Scoring range: Very high pressure = 0 to 5 | High pressure = >6 to 35 | Moderate pressure = >36 to 65 Low pressure = >66 to 79 | Very low pressure = >80 to 100 |

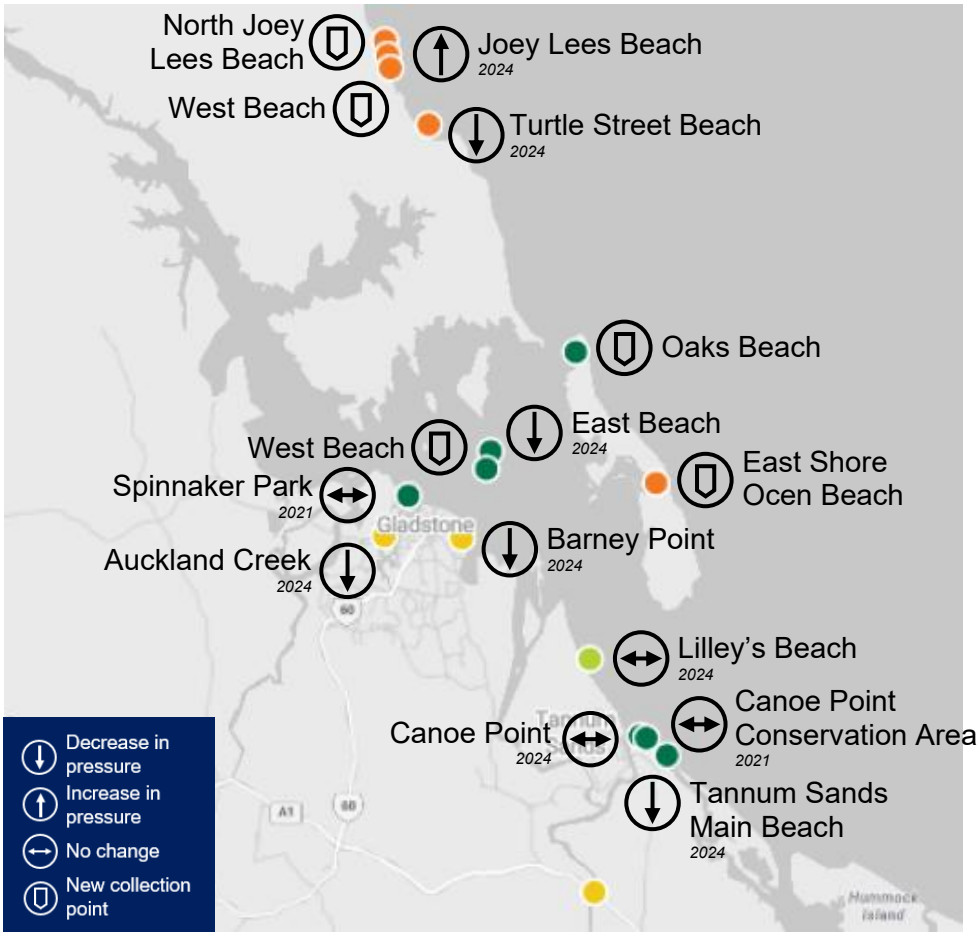

Figure 8.2 | Map and grades of total litter at 14 Gladstone Harbour sites in the 2024–25 reporting year. Scoring range**:** ● Very high pressure = 0 to 5 | ● High pressure = >6 to 35 | ● Moderate pressure = >36 to 65 | ● Low pressure = >66 to 79 | ● Very low pressure = >80 to 100.

9 Gladstone Harbour drivers and pressures

9.1 Background

Drivers and pressures are external forces that play key roles in the health of Gladstone Harbour. As a busy industrialised harbour in a subtropical climate with distinct wet and dry seasons, Gladstone Harbour is influenced by a number of environmental, social, cultural and economic drivers. Changes in the demographics of the human population or major climatic events are examples of drivers; both may have strong influences over the environmental, social, cultural and economic condition of the harbour (McIntosh et al., 2014; Figure 9.1). Pressures are the human forces that may change the environmental condition of the harbour. Examples of pressures are the release of toxic material, physical disturbance of habitats such as mangroves or seagrass, and alterations to the coastline (McIntosh et al., 2014; Figure 9.2).

The Environmental, Social, Cultural and Economic Health of Gladstone Harbour could be influenced by major events that operate on scales that extend spatially or temporally beyond the reporting boundaries specified for the four components. For instance, connectivity may be driven by changes in oceanic circulation and wind and rainfall patterns; water chemistry may be influenced by pressures originating from human activities in river catchments. This section summarises some key drivers and pressures that may have influenced the 2026 Gladstone Harbour Report Card scores.



Figure 9.1 | Major drivers of environmental change within Gladstone Harbour (Source: McIntosh et al., 2014).

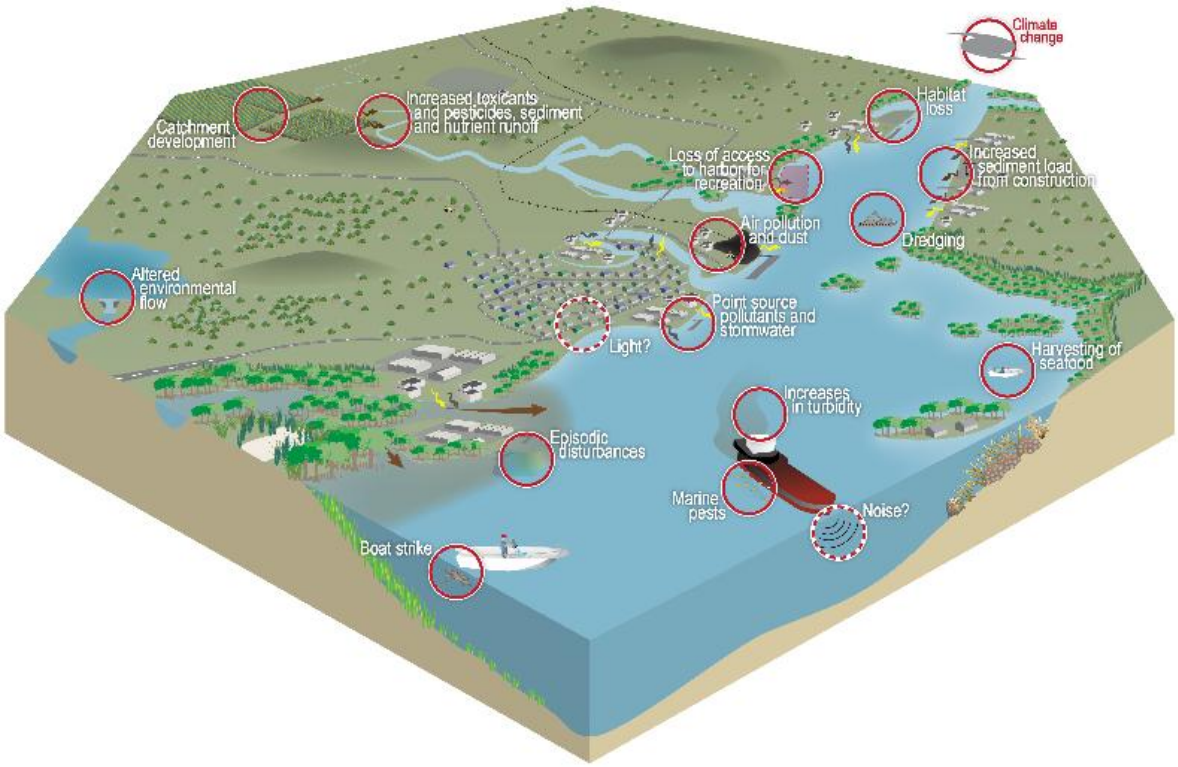

Figure 9.2 | Pressures which can drive environmental change within Gladstone Harbour (Source: McIntosh et al., 2014).

9.2 Climate

Temperature

Gladstone has a subtropical climate with an average maximum of 27.5˚C and an average minimum of 18.2˚C (Figure 9.3).

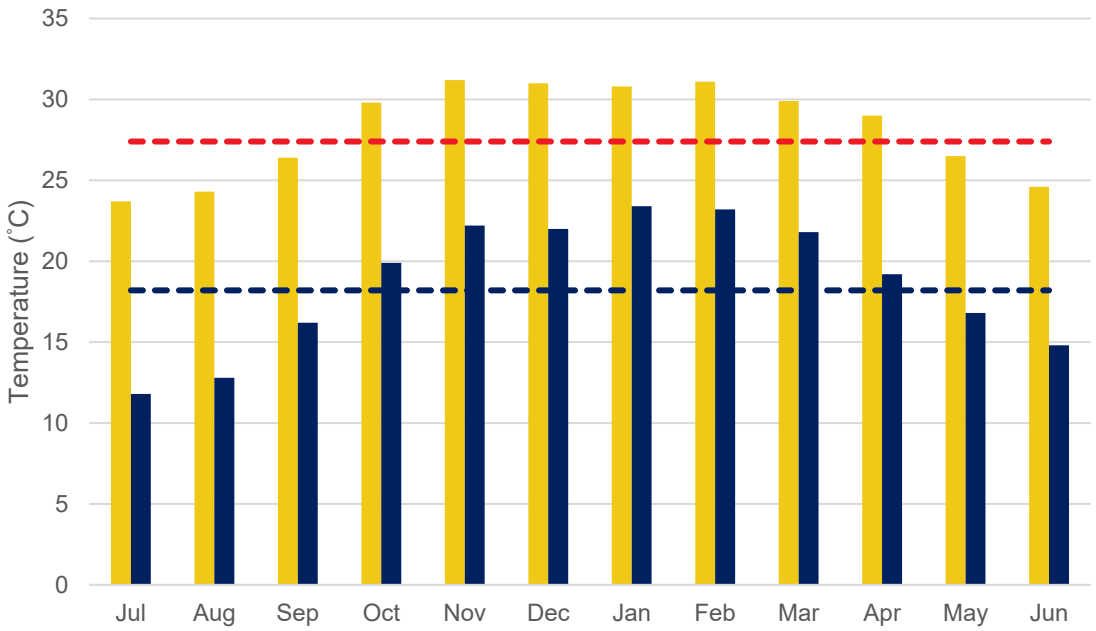

Figure 9.3 | Average maximum and minimum monthly temperatures at the Gladstone Airport weather station for the 2025–26 reporting period (July 2025–June 2026). The average maximum monthly (yellow bars) and average minimum monthly (dark blue bars) for the 2023-24 reporting period are shown in comparison to the 1994–26 annual maximum average (red dashed line, 27.4˚C) and minimum average (blue dashed line, 18.2˚C). Values obtained from BOM (http://www.bom.gov.au/climate/data/index.shtml).

Rainfall

Rainfall is highly variable; the average annual rainfall recorded at Gladstone (Airport) for the period 1994–26 was 860 mm. The maximum and minimum annual rainfall totals recorded at this site were 1,542 mm in 2010 and 308 mm in 2001 respectively. Consistent with a subtropical climate, the summer months are wetter than winter months (BOM, 2024).

In the 2026 reporting year (1 July 2025 to 30 June 2026), total rainfall recorded at Gladstone Airport was 947 mm. This was more than the 1994–26 average (860 mm) (Figure 9.4). Total monthly rainfall was variable when compared to mean monthly rainfall of the past 27 years (Figure 9.5). Two months, November and April, had rainfall totals well above the monthly average, while seven months recorded dryer than average conditions.

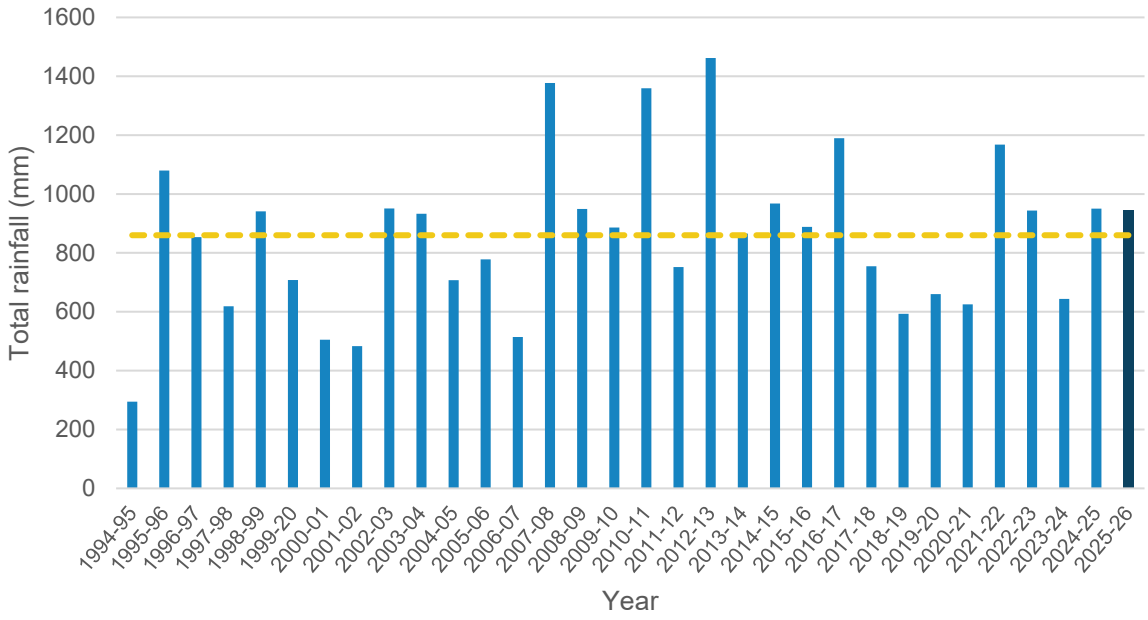

Figure 9.4 | Annual rainfall (mm) by reporting year at the Gladstone Airport weather station from 1994–95 to 2024–25 (light blue bars) and 2025–26 (dark blue bar). Yellow dashed line represents the annual mean for 1994–26 (860 mm). Values were obtained from BOM (http://www.bom.gov.au/climate/data/index.shtml).

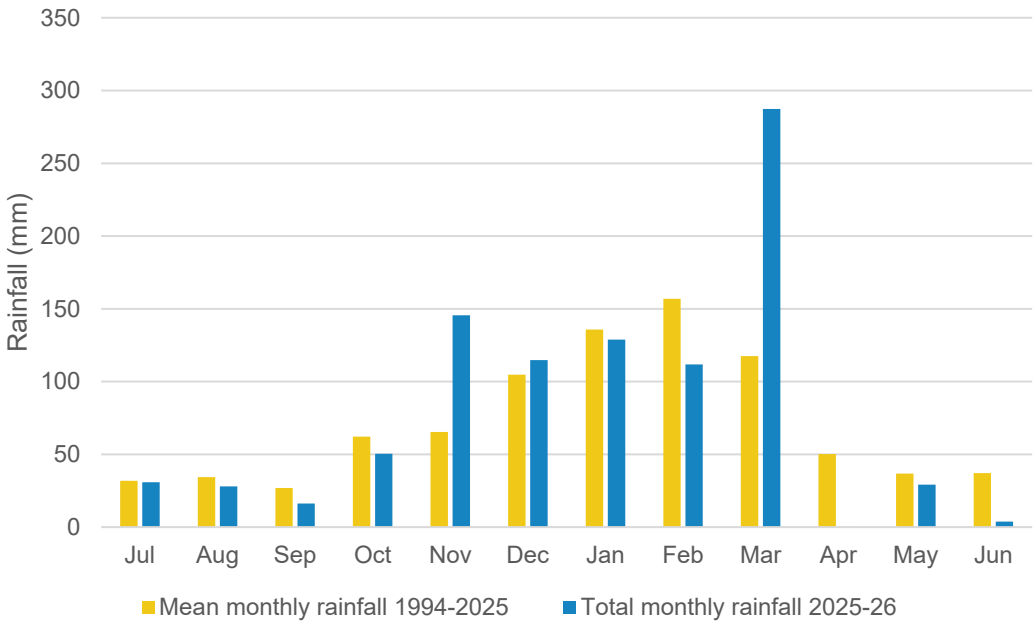

Figure 9.5 | Mean monthly rainfall (mm) at the Gladstone Airport weather station 1994–2025 (yellow bars) compared to total monthly rainfall for the 2025-26 reporting year (blue bars). Values were obtained from BOM (http://www.bom.gov.au/climate/data/index.shtml).

Freshwater inflow

The two major sources of freshwater flow into Gladstone Harbour are the Boyne River that discharges into the Mid Harbour and the Calliope River that discharges into the Western Basin. Small amounts of freshwater flow may also enter the harbour via The Narrows when the Fitzroy River floods. Since European settlement, changes in land use in both catchments have resulted in increased sediment and nutrient loads in the Port of Gladstone (DSEWPaC, 2013).

Streamflow in the Boyne River is highly modified owing to Awoonga Dam, whereas flow in the Calliope River is unaffected. Average annual stream discharges for the Boyne and Calliope rivers are presented in Table 9.1. Average annual stream discharge from the Calliope River is approximately 1.7 times higher than that of the Boyne River.

Flows measured at the Calliope River between January 2014 and June 2024 show two brief but high flow events occurring with the passage of TC Marcia and ex TC Debbie (Figure 9.6). Rainfall associated with TC Marcia caused a peak flow of 91,666 ML/day on 21 February 2015 and rainfall associated with ex TC Debbie produced a peak flow of 105,980 ML/day on 30 March 2017. This compares to a median daily flow of 13.9 ML/day from October 1938 to June 2024 (DRDMW Water Monitoring Information Portal).

In the 2025–26 reporting year, below average rainfall resulted in lower than average monthly discharge volume for all months except November and March (Figure 9.5). Total monthly discharge in November and April was substantially more than the median monthly discharge (1938–2026) (Figure 9.7).

Table 9.1 | Streamflow summary for the Boyne River (1984–85 to 2011–12) and the Calliope River (1938–39 to 2018–19). Source: Queensland Department of Regional Development, Manufacturing and Water (https://water-monitoring.information.qld.gov.au/).

Annual stream discharge (ML)		December stream discharge (ML)	
Boyne River at Awoonga Dam Headwaters (1984–85 to 2011–12)			
Mean	97,728	Mean	24,279
Median	-	Median	-
Maximum flow (2010–11)	1,194,335	Maximum flow (2010–11)	634,999
Calliope River at Castlehope (1938–39 to 2019–20)			
Mean	163,783	Mean	20,724
Median	99,040	Median	2,727
Maximum flow (2012–13)	916,693	Maximum flow (1973–74)	401,837

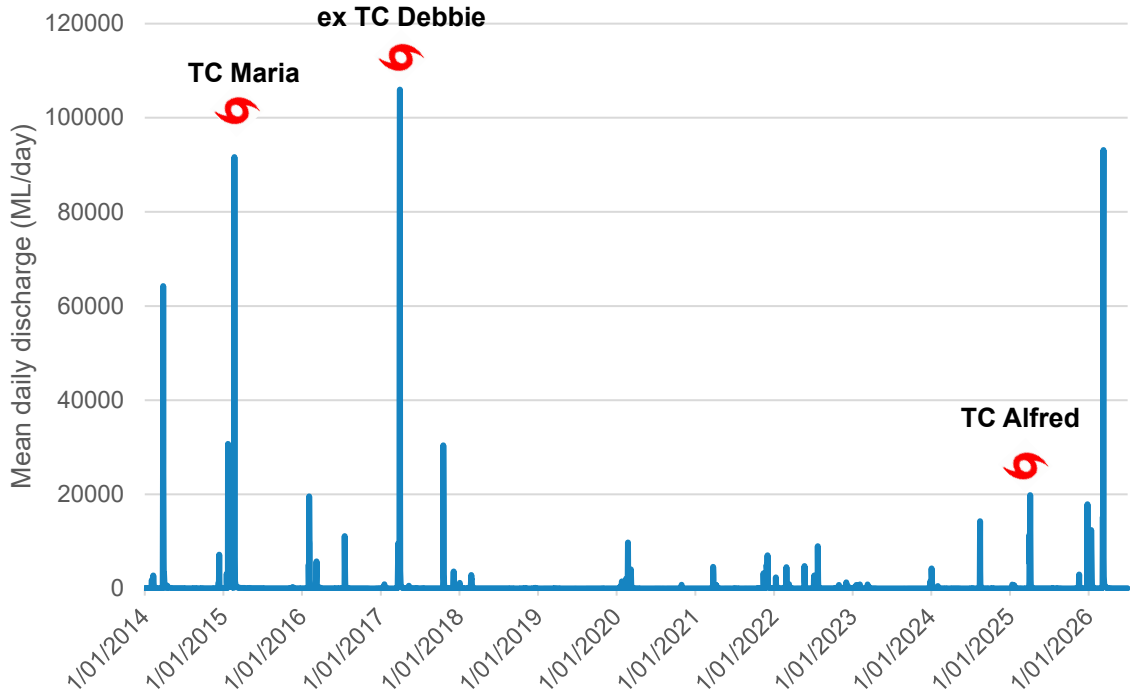

Figure 9.6 | Mean daily Calliope River flows recorded at Castlehope January 2014–June 2026. Values were obtained from Queensland Department of Regional Development, Manufacturing and Water (https://water-monitoring.information.qld.gov.au/).

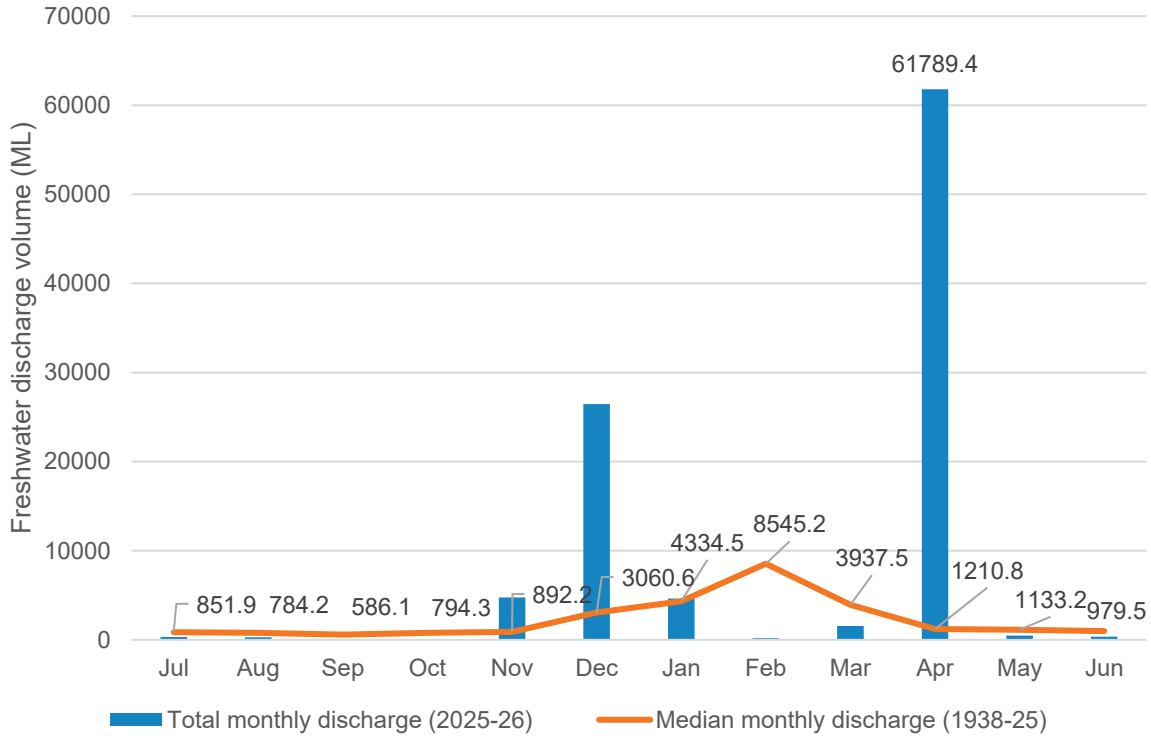

Figure 9.7 | Monthly water discharge for July 2025–June 2026 (blue bars) and median monthly water discharge for October 1938–June 2025 (orange line) of the Calliope River at Castlehope. Values were obtained from Queensland Department of Regional Development, Manufacturing and Water (https://water-monitoring.information.qld.gov.au/).

The main water storage for Gladstone is the Awoonga Dam located on the Boyne River approximately 25 km south-west of Gladstone. The dam has a storage capacity of 250,000 ML and is overtopped when the storage level exceeds 40 m Australian Height Datum (Table 9.2). Since the height of the dam wall was raised in 2002, it has overtopped eight times – in 2002, 2010, 2013, 2015, 2017 and 2018. No overtopping occurred in the 2025–26 report card year.

Table 9.2 | Highest Awoonga Dam levels and last overtopping (Source: Gladstone Area Water Board).

Storage level	Date	Level (m AHD)	Volume (ML)	Capacity (%)	Surface area (ha)
Last overflow of 40m spillway	3 Jan 18	40.30	778,900	100.26	6,791
Highest level	27 Jan 13	48.3	1,498,586	192.9	10,810

AHD – Australian Height Datum

9.3 Land use and catchment run-off

Gladstone Harbour is bordered by five drainage basins, the Fitzroy (142,545 km^2), the Calliope (2,241 km^2), the Boyne (2,496 km^2), Curtis Island (577 km^2) and Baffle Creek (4,085 km^2), data sourced from wetlandinfo.des.qld.gov.au/wetlands/ (Figure 9.8).

The primary sources of riverine discharge into Port Curtis come from the Calliope and Boyne rivers, with some flow through The Narrows when the Fitzroy River is in flood. Compared to the Fitzroy River catchment area (142,665 km^2), the Calliope and Boyne are small with catchment areas of 2,236 km^2 and 2,590 km^2 respectively. The predominant land use within these two catchments is grazing (Figures 9.9 and 9.10). Much of the flow from the Boyne River into Port Curtis is restricted by Awoonga Dam, constructed in phases beginning in the 1960s. The current spillway height of 40 m Australian height datum was achieved in 2002. In periods of normal flow, it would be expected that coarser sediment particles would settle behind the structure.

Catchment run-off can strongly influence water quality within estuarine systems. It is a major source of sediments, nutrients and pesticides delivered to marine waters (Waterhouse et al., 2024). Land use within a catchment will influence the type and volume of material exported from that catchment. Suspended sediments are dominated by grazing inputs, while pesticides and nutrients are sourced from dryland and irrigated cropping and grazing lands (Waterhouse et al., 2024).

Turbidity in Gladstone Harbour is also strongly influenced by the large tidal movements. This results in resuspension of fine sediments which is directly related to the tidal cycle; larger tides result in increased turbidity (Figure 9.11). Turbidity levels in Gladstone Harbour tend to be much higher on falling tides than on rising tides (Baird and Margvelasvili, 2015). Collecting water quality samples throughout the day provides samples at various times in the tidal cycle. Thus, the measured variation in turbidity among sites can be influenced by the timing of sampling.

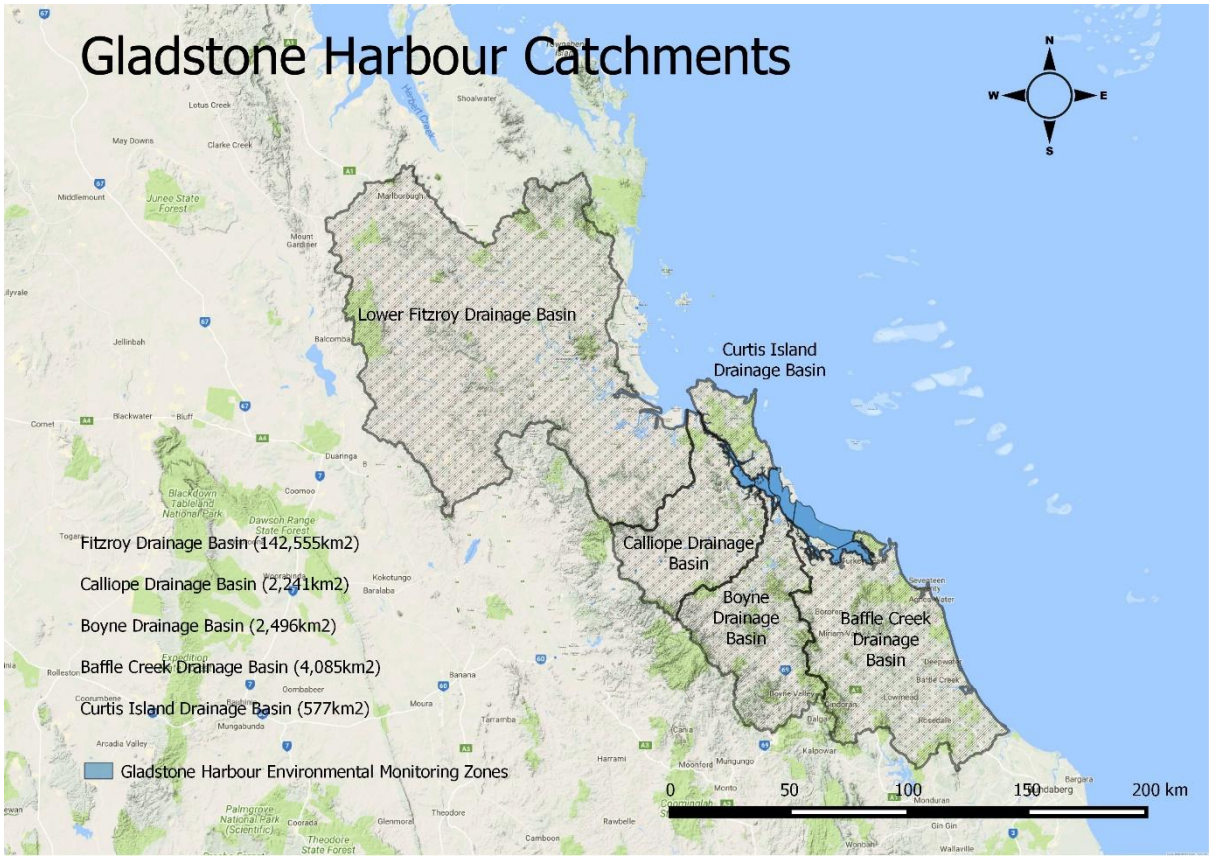

Figure 9.8 | Drainage basins surrounding the Gladstone Harbour environmental monitoring zones. Adapted from data available at wetlandinfo.des.qld.gov.au/wetlands/.

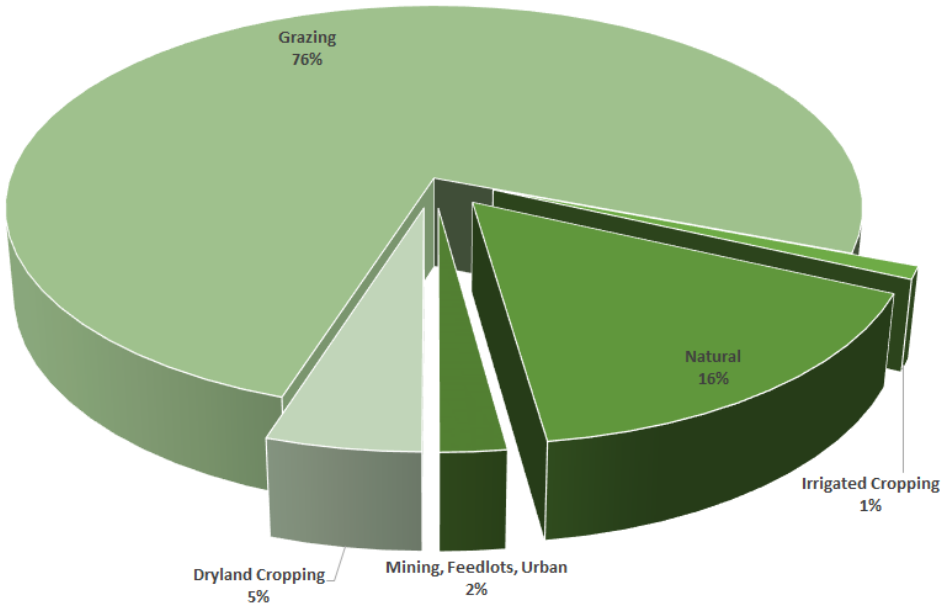

Figure 9.9 | Land use in the Boyne catchment (Data source QSpatial, Land use mapping – Fitzroy NRM region 2009, Catchment boundaries, Queensland Wetland*Info*).

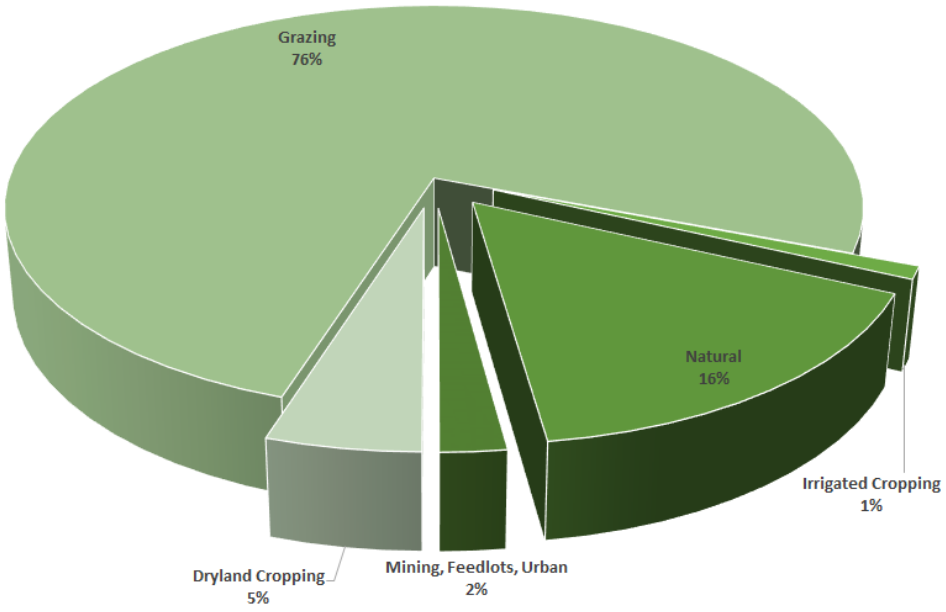

Figure 9.10 | Land use in the Calliope catchment (Data source QSpatial, Land use mapping – Fitzroy NRM region 2009, Catchment boundaries, Queensland Wetland*Info*).

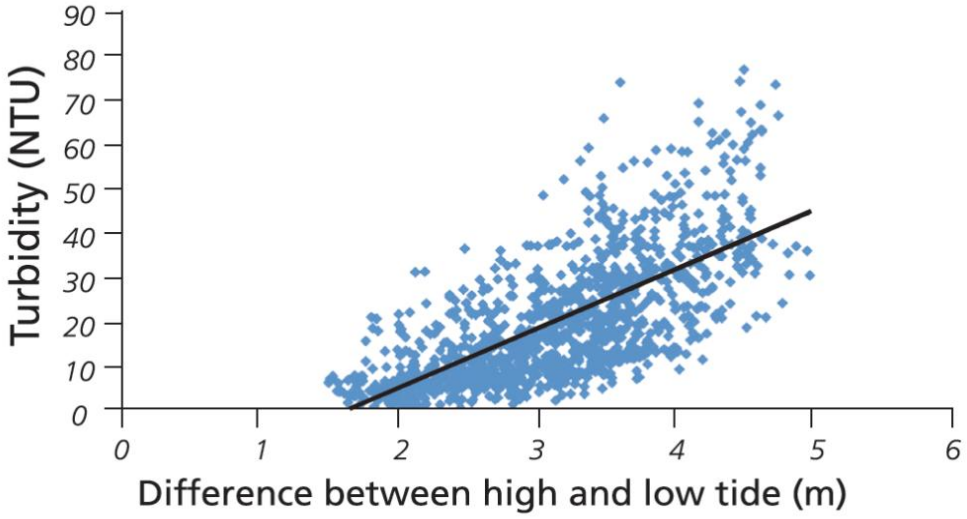

Figure 9.11 | The relationship between tidal movement and turbidity in Gladstone Harbour (DEHP, 2014; personal communication). NTU: nephelometric turbidity unit.

10 Guide to the infrastructure supporting the report card

10.1 Data Information Management System

The GHHP Data Information Management System (DIMS) is an essential infrastructure developed by the AIMS which allows a range of users to store, calculate and visualise report card raw data and results (Figure 10.1). Given the large social, cultural, economic and environment monitoring datasets used to inform a report card, this system helps to manage the data systematically and consistently with a reliable backup system. The DIMS is also an information source for the website that can collate and analyse different data types and produce graphical outputs and tables.

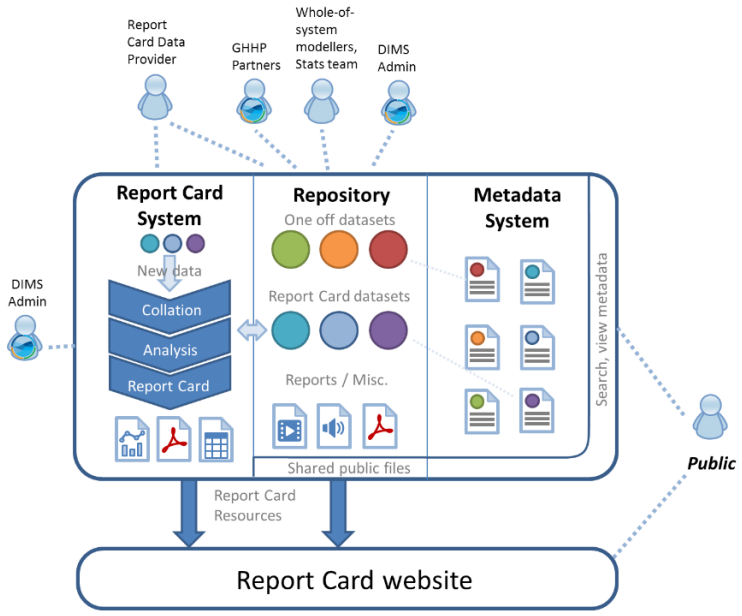

Figure 10.1 | Schematic diagram of the links between the report card website and the Data Information Management System (DIMS) to illustrate major components and primary inputs and outputs (Diagram courtesy of AIMS).

The DIMS server consists of the following four key components:

1. Metadata system – This is a metadata catalogue and provides public access to all metadata records related to report card raw data. The metadata system ensures that all raw data in the DIMS are documented appropriately using ISO19115 Marine Community Profile metadata standard. This system consists of a metadata entry system based on open-source metadata catalogue software Geo Network and a public front-end based on the e-Portal Metadata Viewer.
2. DIMS repository – This is a web-based, file-sharing and storage application that provides storage for all report card-related files. The DIMS repository is based on Pydio open-source, file-sharing platform.
3. Report card system – This is the core of the DIMS that is responsible for data ingest, script execution and report card score generation for review by the GHHP Independent Science Panel. The report card system is based on Java servlet, Ember.js and R programming language (Figure 10.2).

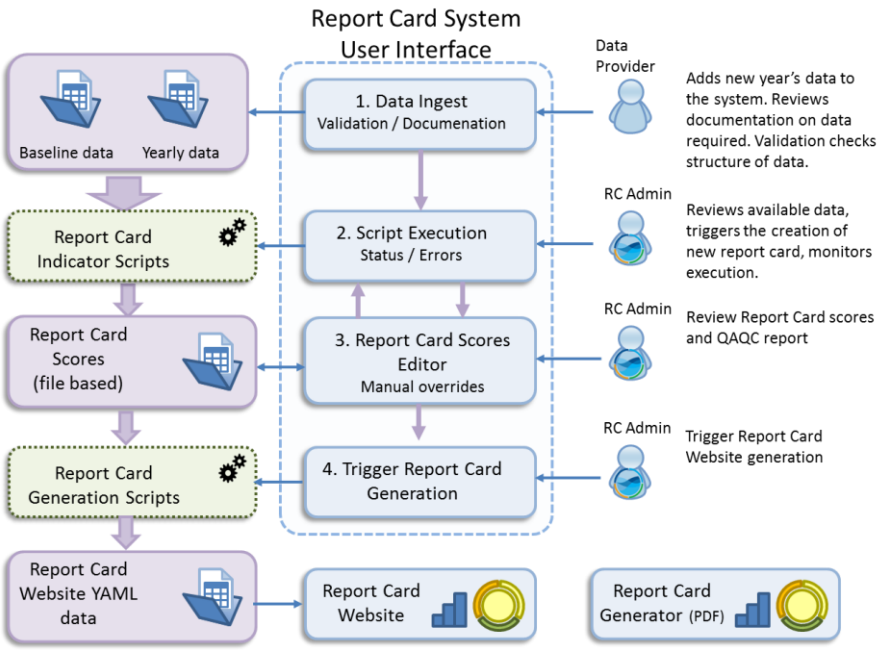

Figure 10.2 | Schematic diagram of the report card system showing all data ingestion, script execution and report cards results generation modules (Diagram courtesy of AIMS).

To enable DIMS to perform the above tasks, a range of off-the-shelf and custom-built software packages has been deployed on Amazon server Amazon EC2 (Elastic Cloud Virtual Servicers) with S3 (reliable storage services) backup (Figure 10.3). This approach makes the system highly portable and not dependent on AIMS systems. A core advantage of using the Amazon system for backup is its ability to scale-up the server capacity as the needs of the DIMS services expand over time.

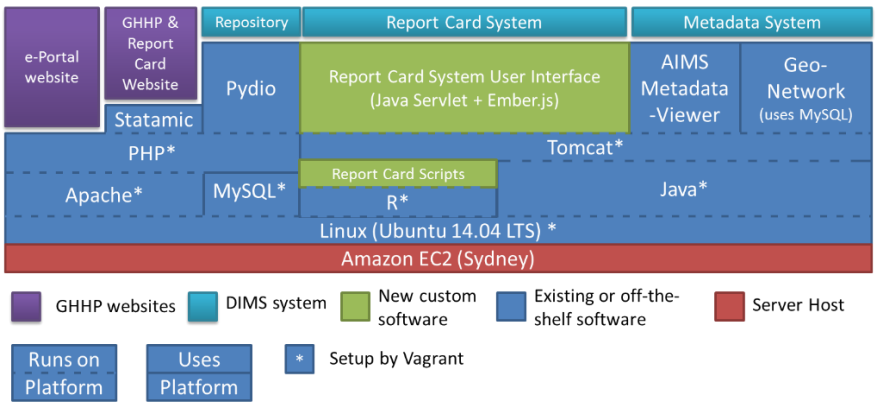

Figure 10.3 | Software infrastructure underlying the Data Information Management System (DIMS) operations (Diagram courtesy of AIMS).

11 Geographical scope

11.1 Environmental reporting zones

The 13 environmental reporting zones in Gladstone Harbour have developed over time from an initial seven zones proposed by Jones et al. (2005) in a risk assessment for contaminants in Gladstone Harbour. In their 2007 Port Curtis Ecosystem Health Report Card, PCIMP increased the number of zones to nine by including oceanic and estuarine reference sites (Storey et al., 2007). However, these two reference zones were combined in the 2011 Port Curtis Ecosystem Health Report Card (Vision Environment QLD, 2011) resulting in eight zones. The DEHP developed the current 13 zones (Figure 11.1). These zones were also used to define regionally specific Water Quality Objectives for the Capricorn Coast (DEHP, 2014).

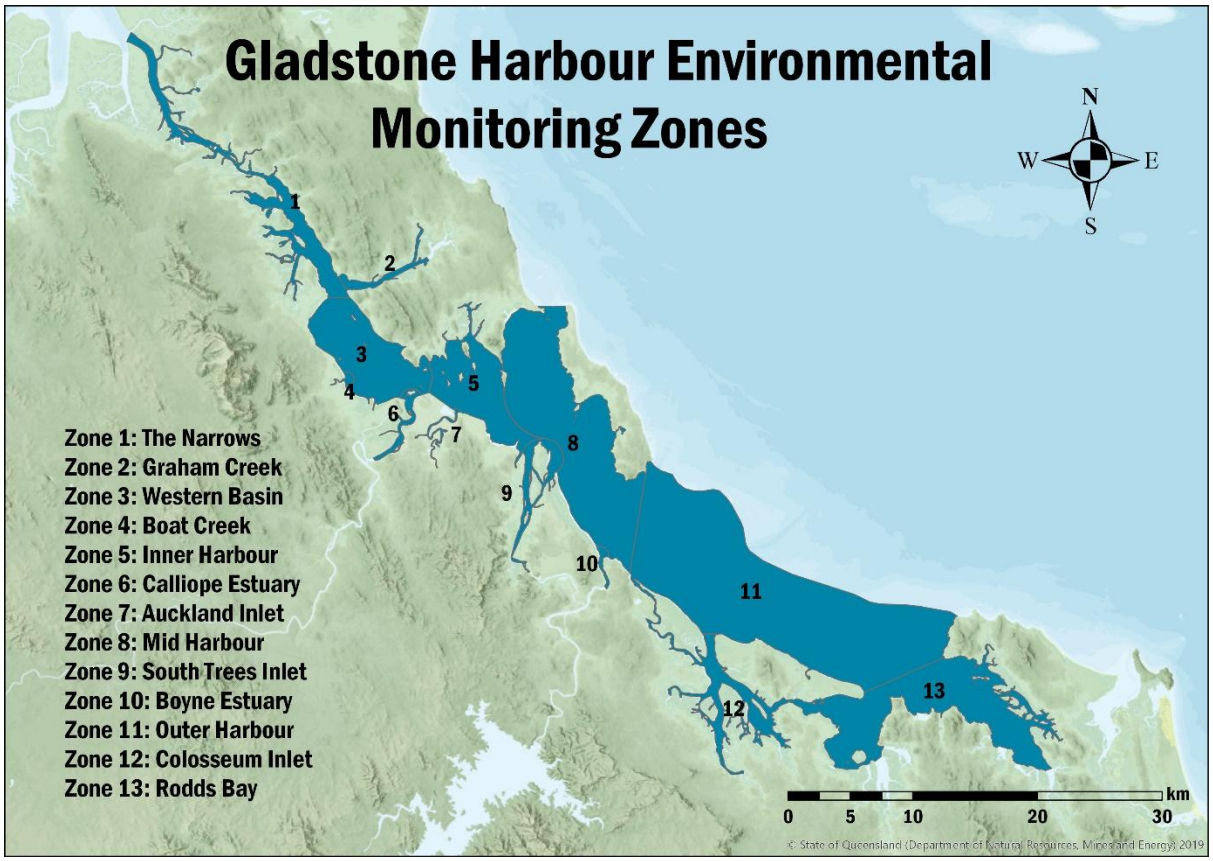

Figure 11.1 | The 13 Gladstone Harbour zones for which environmental parameters were measured for the 2026 Gladstone Harbour Report Card.

11.1.1 The Narrows



Figure 11.2 | Habitat types and sampling sites in The Narrows.

MONITORING SITES

Water and Sediment Quality	6
Seagrass	1
Fish Recruitment	2
Mud Crab	1
Fish Health	Yes

The Narrows is the northern outlet of Gladstone Harbour. It connects the harbour to Keppel Bay near the mouth of the Fitzroy River and separates Curtis Island from the mainland. Curtis Island has a number of conservation zones including national parks, regional parks and state forests and is considered to have environmental and cultural value (Commonwealth of Australia, 2013). The Narrows is lined by mangroves and saltmarsh; it provides sheltered water and is an important area for recreational and commercial fisheries (Vision Environment QLD, 2011). This zone has one monitored seagrass meadow—an intertidal meadow comprising aggregated patches of seagrass near Black Swan Island.



Figure 11.3 | The Narrows photographed from the south with Keppel Bay in the distance.

11.1.2 Graham Creek

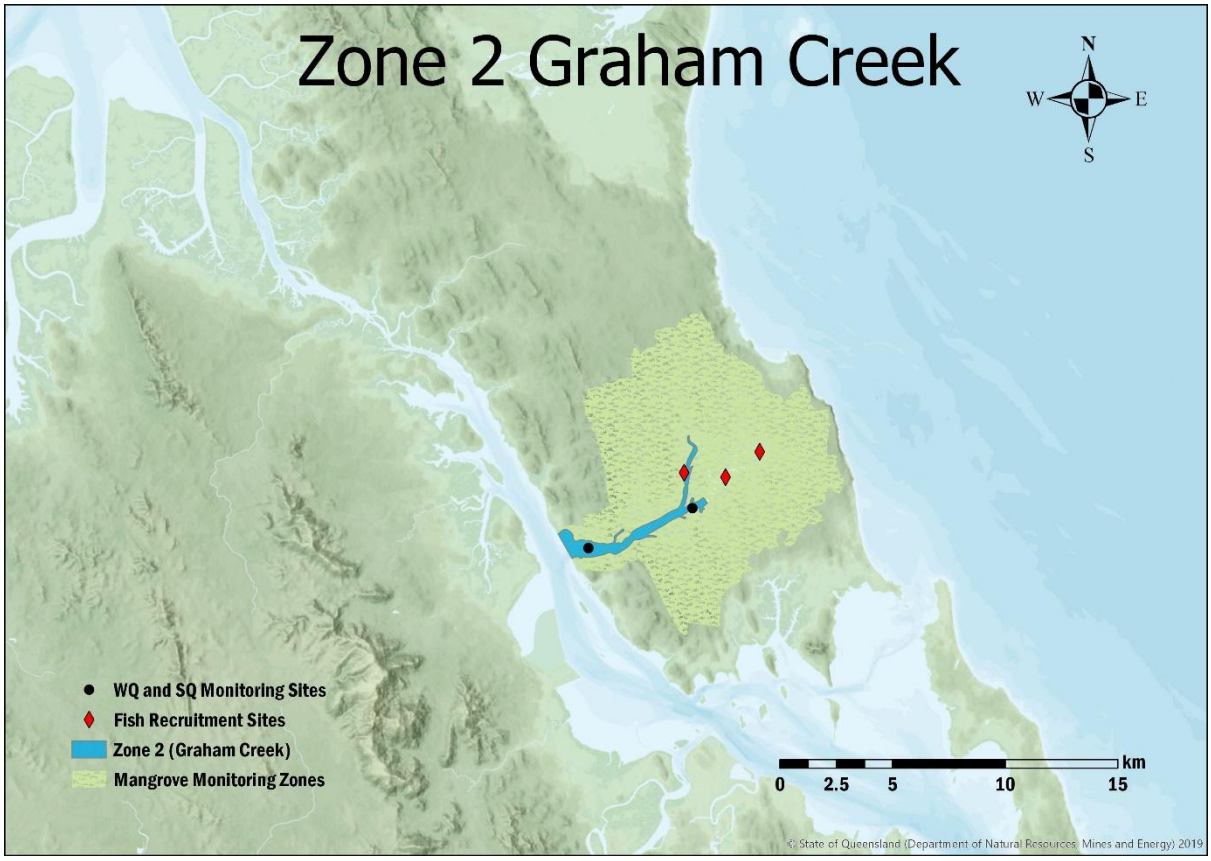

Figure 11.4 | Habitat types and sampling sites in Graham Creek.

MONITORING SITES

Water and Sediment Quality	2
Seagrass	0
Fish Recruitment	3
Mud Crab	1
Fish Health	Yes

Graham Creek is a mangrove-lined tidal inlet located near the south-west corner of Curtis Island. It is approximately 9 km long and flows into the southern end of The Narrows. It is considered one of the best fishing spots in Gladstone Harbour. Three major creeks – Rawbelle, Hobble Gully and Logbridge – flow into Graham Creek.



Figure 11.5 | The south-western end of Curtis Island photographed from the north. Graham Creek is in the middle of the picture and the Western Basin is in the distance.

11.1.3 Western Basin

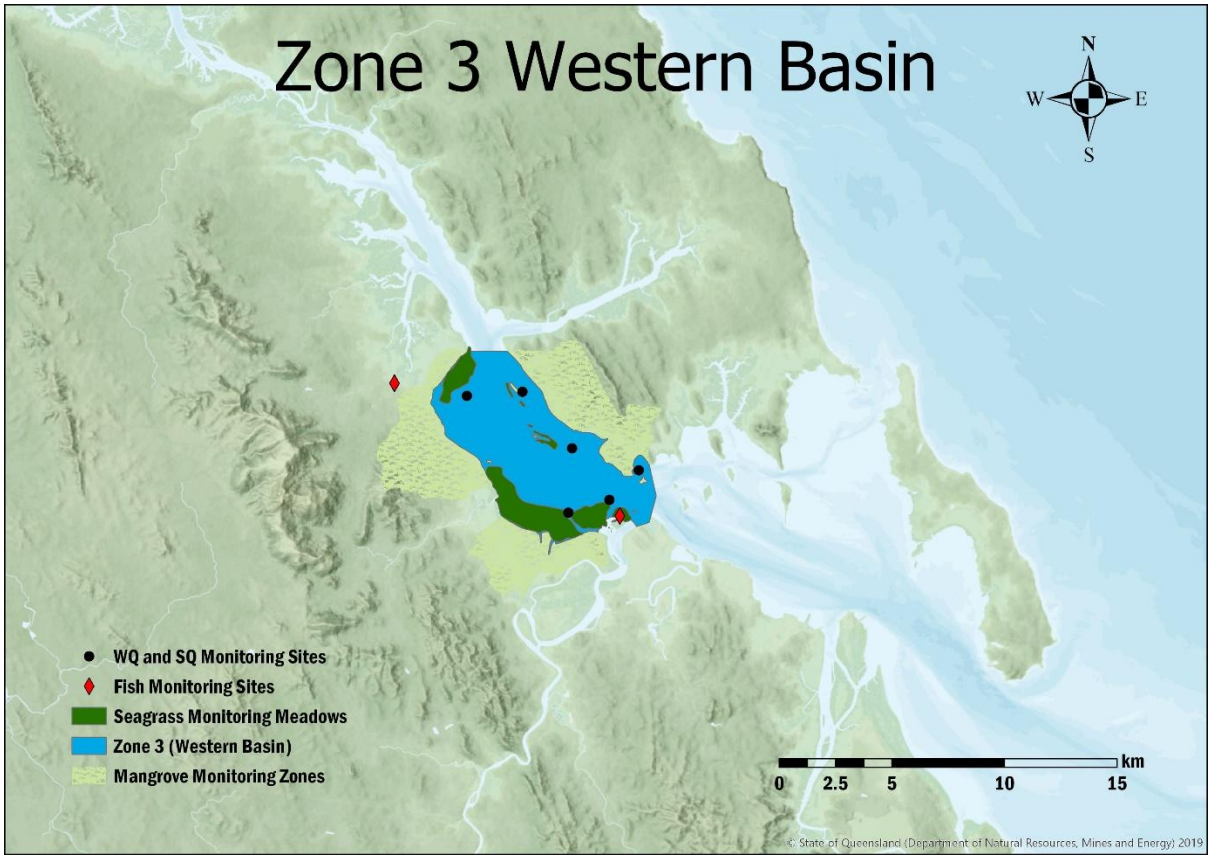

Figure 11.6 | Habitat types and sampling sites in the Western Basin.

MONITORING SITES

Water and Sediment Quality	6
Seagrass	6
Fish Recruitment	2
Mud Crab	0
Fish Health	Yes

The Western Basin is located near the north-western end of Gladstone Harbour. Three large-scale liquid natural gas plants have been constructed on the south-western shore of Curtis Island. The first of these started operating in late 2014. Large industrial plants located on the western shore of this zone include Queensland Energy Resources, Rio Tinto Yarwun, Orica, Transpacific Waste and Cement Australia. The zone includes six monitored seagrass meadows. Areas of mangroves and mudflats remain between Fisherman's Landing and the Wiggins Island Coal Export Terminal (WICET) and on the southern tip of Curtis Island.



Figure 11.7 | The south-western corner of Curtis Island, showing two liquid nitrogen gas plants in the foreground and the Western Basin in the distance.

11.1.4 Boat Creek

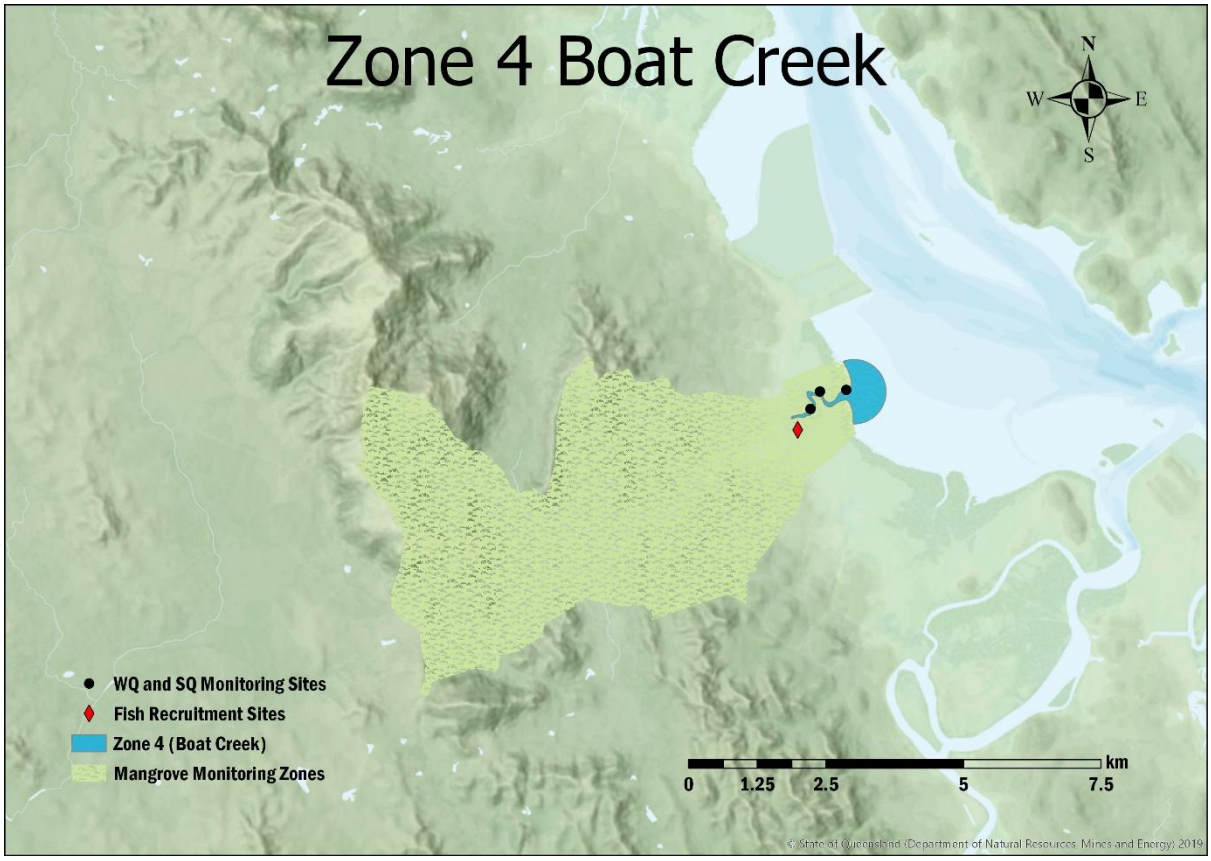

Figure 11.8 | Habitat types and sampling sites in Boat Creek.

MONITORING SITES

Water and Sediment Quality	3
Seagrass	0
Fish Recruitment	2
Mud Crab	1
Fish Health	No

Boat Creek is a small mangrove-lined estuary connected to the western side of the Western Basin. This long (approximately 9 km), narrow water body is not well flushed during regular tides. It is a small zone that includes 2 km of waterway and a small open harbour area near the mouth.



Figure 11.9 | Inlet to Boat Creek photographed from the Western Basin.

11.1.5 Inner Harbour

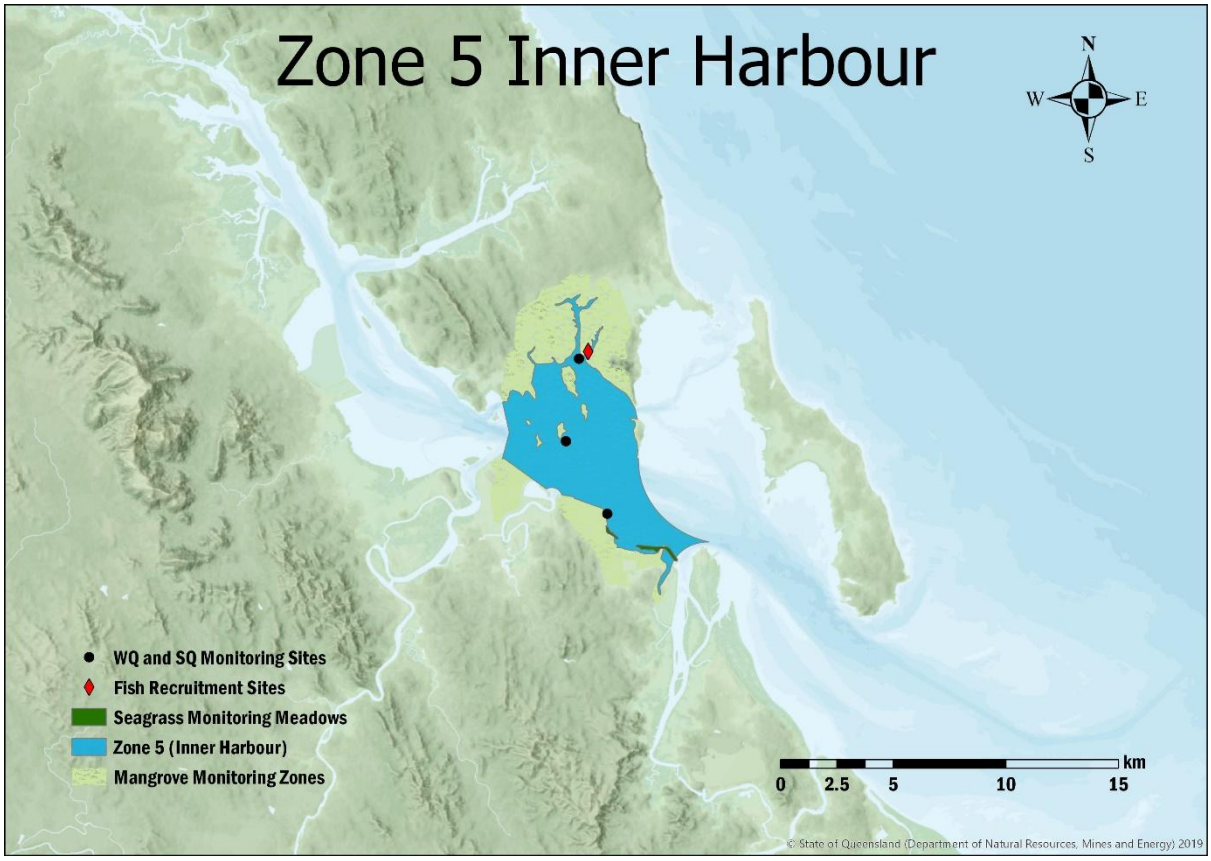

Figure 11.10 | Habitat types and sampling sites in the Inner Harbour.

MONITORING SITES

Water and Sediment Quality	3
Seagrass	1
Fish Recruitment	2
Mud Crab	1
Fish Health	Yes

The Inner Harbour is located immediately to the east of the Western Basin and is bounded by a mangrove-dominated intertidal system on Curtis Island and the town of Gladstone on the southern edge. Coral reefs have been recorded at Turtle, Quoin and Diamantina Islands although there is little evidence that these areas have recently supported viable coral communities (BMT WBM, 2013). There are several seagrass meadows, including one that is monitored in the south of this zone.

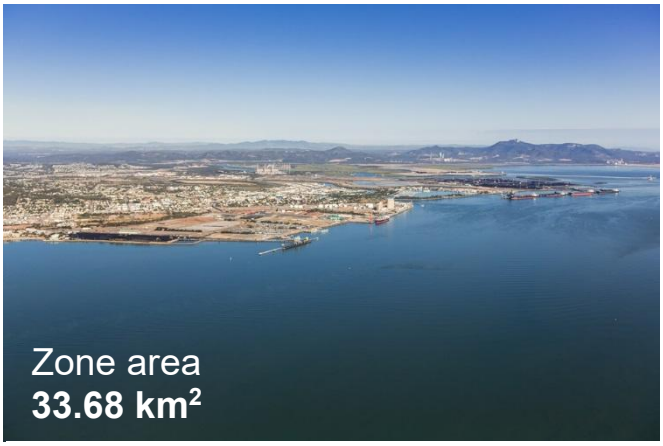

Figure 11.11 | The Inner Harbour photographed from the north-east, with Auckland Point wharves and the City of Gladstone on the left and the RG Tanna Coal Terminal on the right.

11.1.6 Calliope Estuary

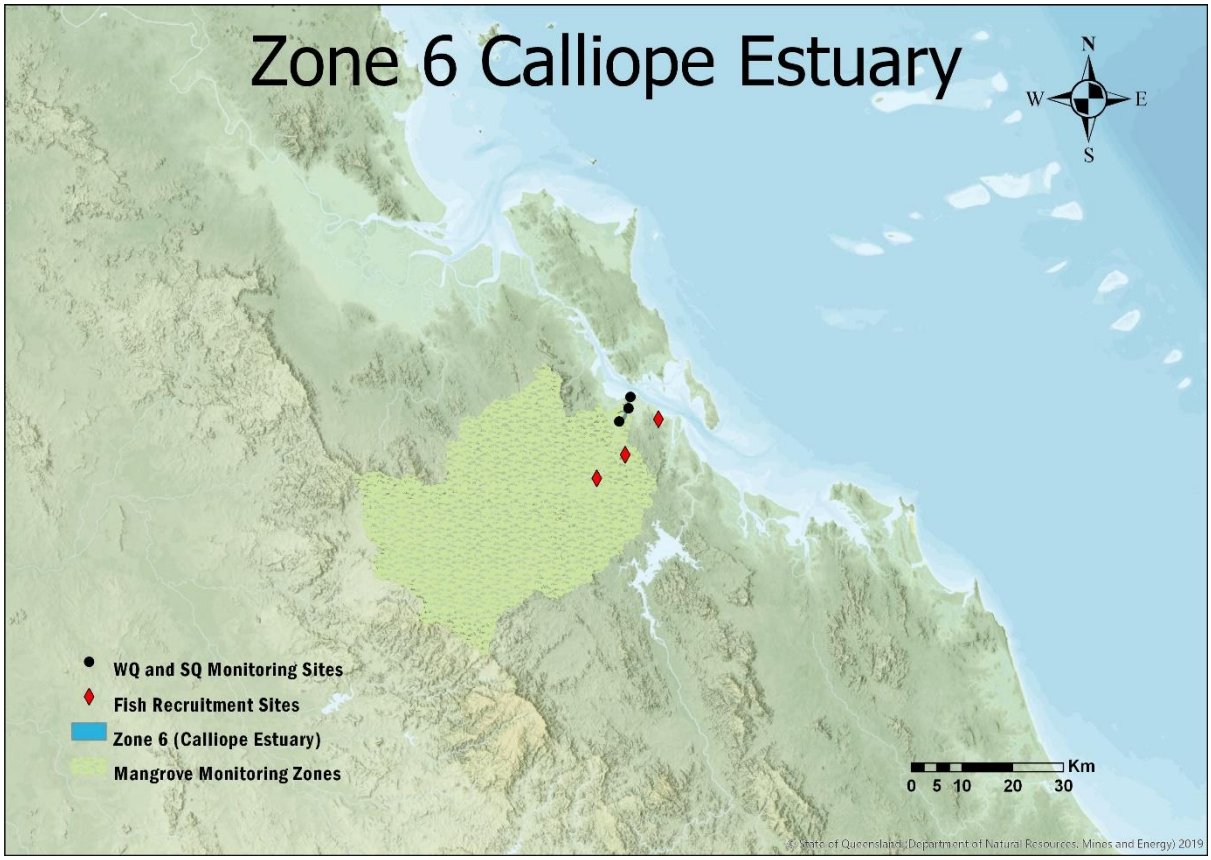

Figure 11.12 | Habitat types and sampling sites in Calliope Estuary.

MONITORING SITES

Water and Sediment Quality	3
Seagrass	0
Fish Recruitment	2
Mud Crab	1
Fish Health	Yes

The Calliope River is fed by Gladstone Harbour's largest freshwater catchment. The river's main tributaries include Oakey, Paddock, Double and Larcom creeks. The Calliope River flows into the Western Basin and is a source of turbid freshwater during floods or other high flow events. The WICET and the RG Tanna Coal Terminal are located at the mouth of the Calliope Estuary. Queensland's largest coal-fired power station is located alongside the Calliope Estuary, approximately 4 km upstream from the river mouth, and has been operating since 1976.



Figure 11.13 | The Gladstone coal-fired power station, on the banks of the Calliope Estuary photographed from the north-east.

11.1.7 Auckland Inlet

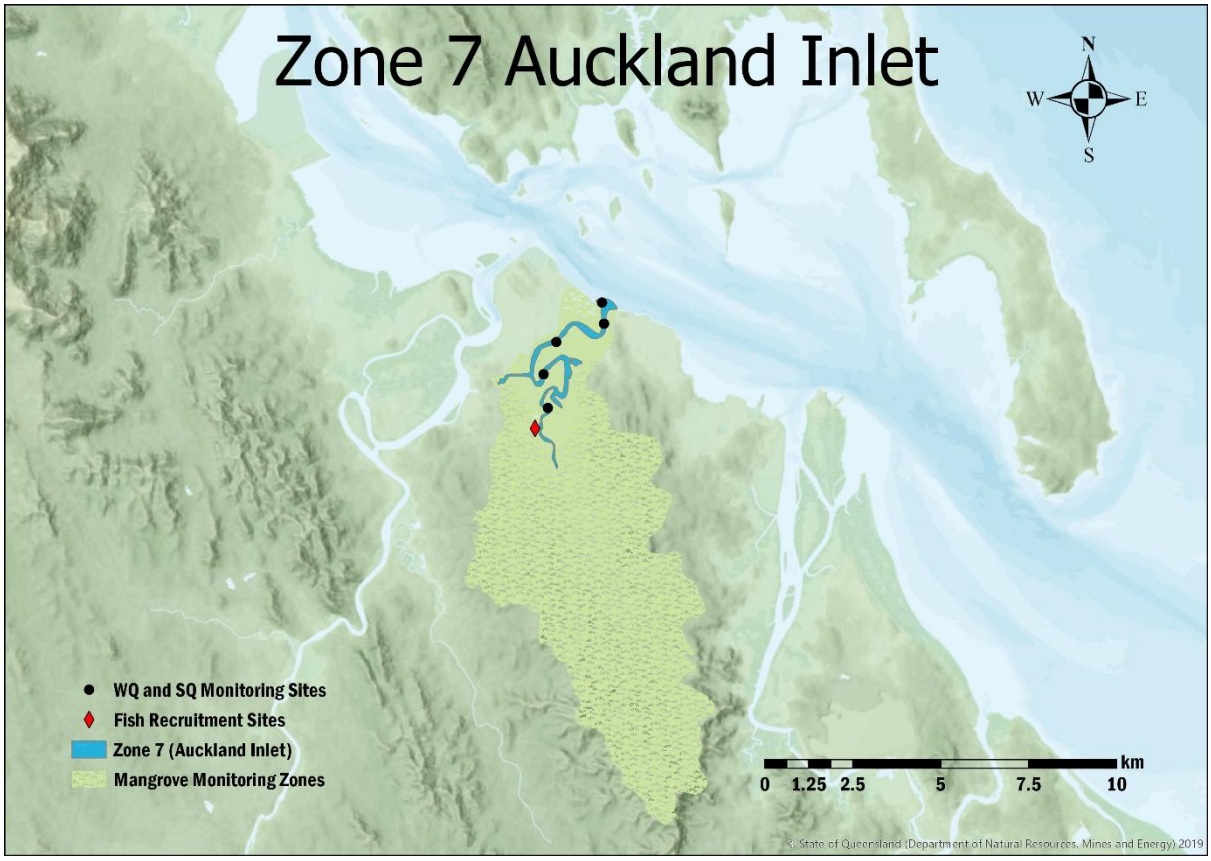

Figure 11.14 | Habitat types and sampling sites in Auckland Inlet.

MONITORING SITES

Water and Sediment Quality	5
Seagrass	0
Fish Recruitment	1
Mud Crab	1
Fish Health	Yes

Auckland Inlet is a tidal inlet that connects to the Inner Harbour through a complex of small streams meandering through mangrove-lined mudflats that are often inundated at high tide. Seawater extracted from Auckland Creek is used to cool the Gladstone Power Station. Stormwater run-off outlets are located along Auckland Creek.



Figure 11.15 | Auckland Inlet photographed from the south-west. Gladstone Marina is in the middle ground and the Auckland Point Terminal to the left.

11.1.8 Mid Harbour

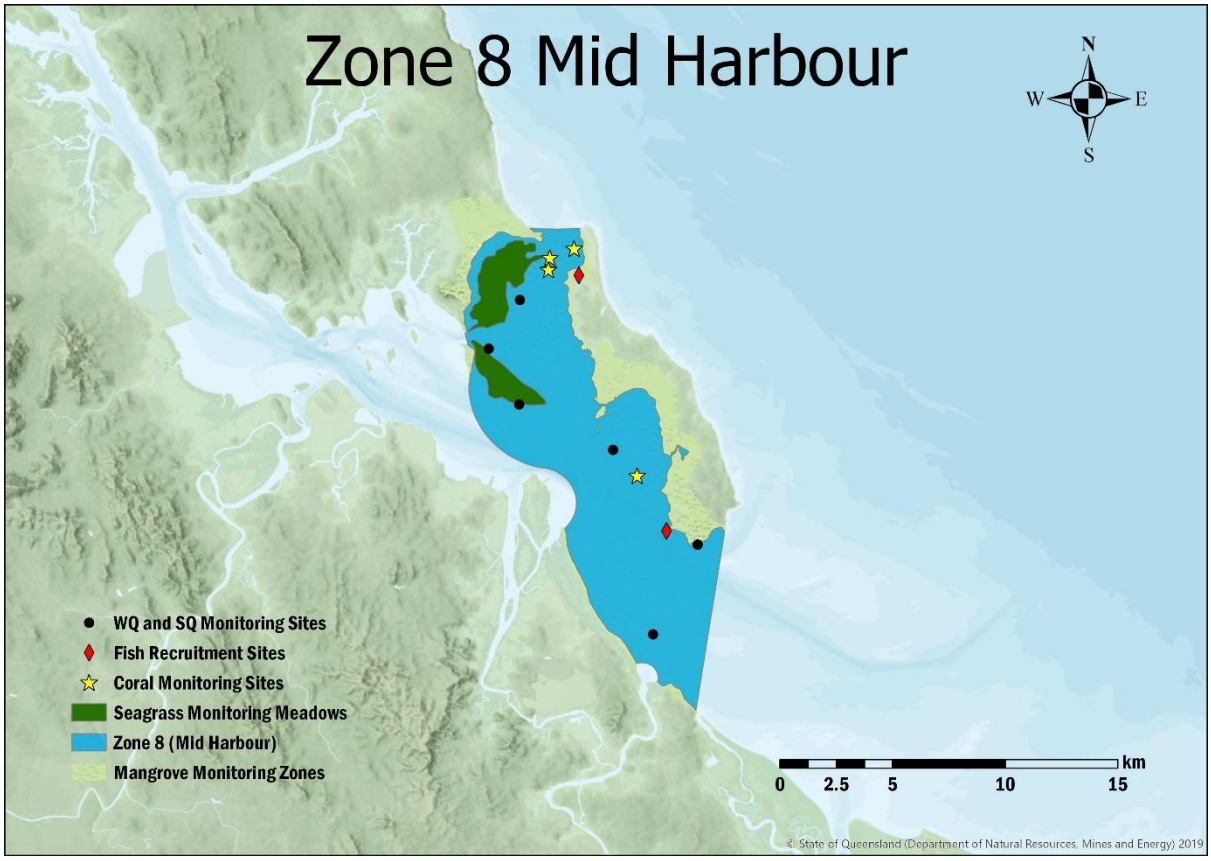

Figure 11.16 | Habitat types and sampling sites in the Mid Harbour.

MONITORING SITES

Water and Sediment Quality	6
Seagrass	2
Fish Recruitment	2
Mud Crab	0
Fish Health	Yes
Coral	4

The Mid Harbour is the second largest of the harbour zones and is bounded by Facing, Curtis and Boyne islands. Most shipping enters the harbour along the Gatcombe channels in the southern end of this zone. This zone contains two monitored seagrass meadows, including the largest seagrass meadow in the harbour at Pelican Banks. Within the zone, coral reefs occur along the western side of Facing Island and on the south-east tip of Curtis Island. There are four coral monitoring sites in this zone that are adjacent to the Great Barrier Reef Marine Park.



Figure 11.17 | Auckland Inlet photographed from the south-west. Gladstone Marina is in the middle ground and the Auckland Point Terminal to the left.

11.1.9 South Trees Inlet

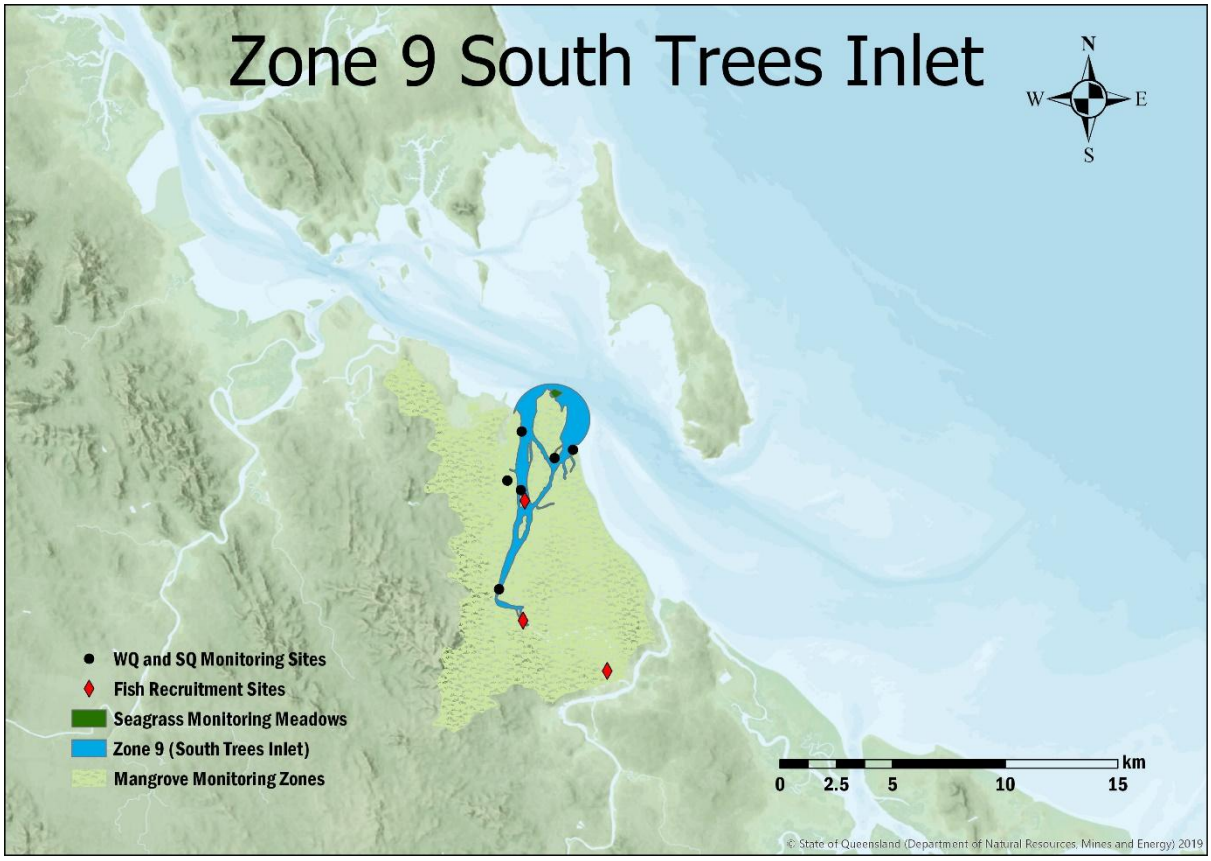

Figure 11.18 | Habitat types and sampling sites in South Trees Inlet.

MONITORING SITES

Water and Sediment Quality	6
Seagrass	1
Fish Recruitment	2
Mud Crab	0
Fish Health	Yes

South Trees Inlet is a mangrove and salt pan-lined tidal inlet that flows into the Mid Harbour zone. The zone contains one monitored seagrass meadow which sits just off the northern tip of South Trees Island. At 10.9 ha it is the second smallest of the monitored meadows. The area contains a large number of industrial developments, including South Trees Wharf on South Trees Island at the inlet's mouth, Queensland Alumina Ltd to the west of the inlet, and Boyne smelters to the south-west of the inlet. The South Trees Industrial Estate is located next to Wapentake Creek which flows into the western side of the inlet just south of South Trees Island.



Figure 11.19 | The mouth of South Trees Inlet photographed from the north, showing South Trees Island in the foreground and Boyne Island in the background.

11.1.10 Boyne Estuary

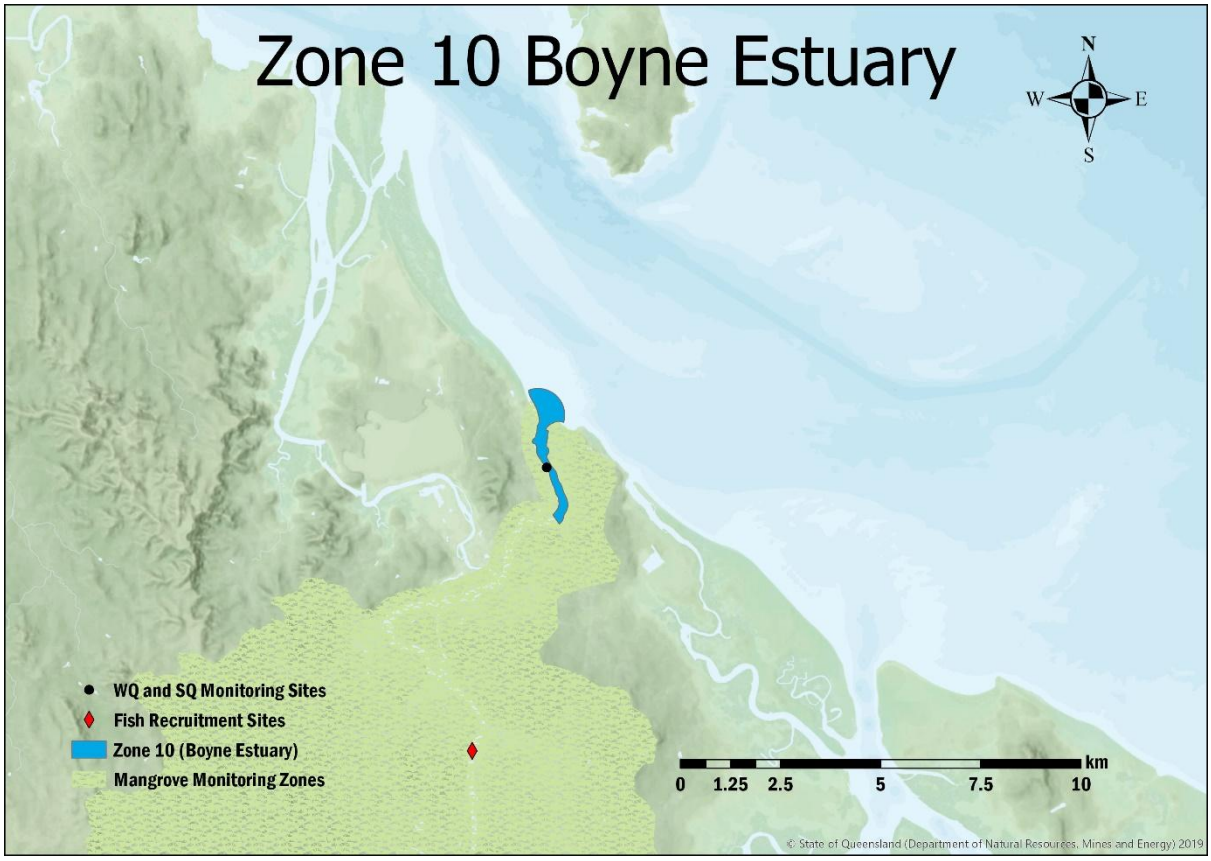

Figure 11.20 | Habitat types and sampling sites in Boyne Estuary.

MONITORING SITES

Water and Sediment Quality	1
Seagrass	0
Fish Recruitment	2
Mud Crab	0
Fish Health	Yes

The Boyne River is dammed at Lake Awoonga to provide potable water for the Gladstone area. Large numbers of Barranundi are stocked in Lake Awoonga and may be introduced into the Boyne Estuary when the dam overtops. The Boyne Estuary was the site of large-scale mortality of many of these introduced Barranundi and other fish in 2011. The lower reach of the Boyne River flows from the dam through predominantly agricultural land that has pockets of remnant vegetation. Before entering the south-eastern section of the Mid Harbour zone, the Boyne River flows through the residential communities of Boyne Island and Tannum Sands.



Figure 11.21 | The mouth of the Boyne River photographed from the north-east. Boyne Island is on the right and Tannum Sands on the left.

11.1.11 Outer Harbour

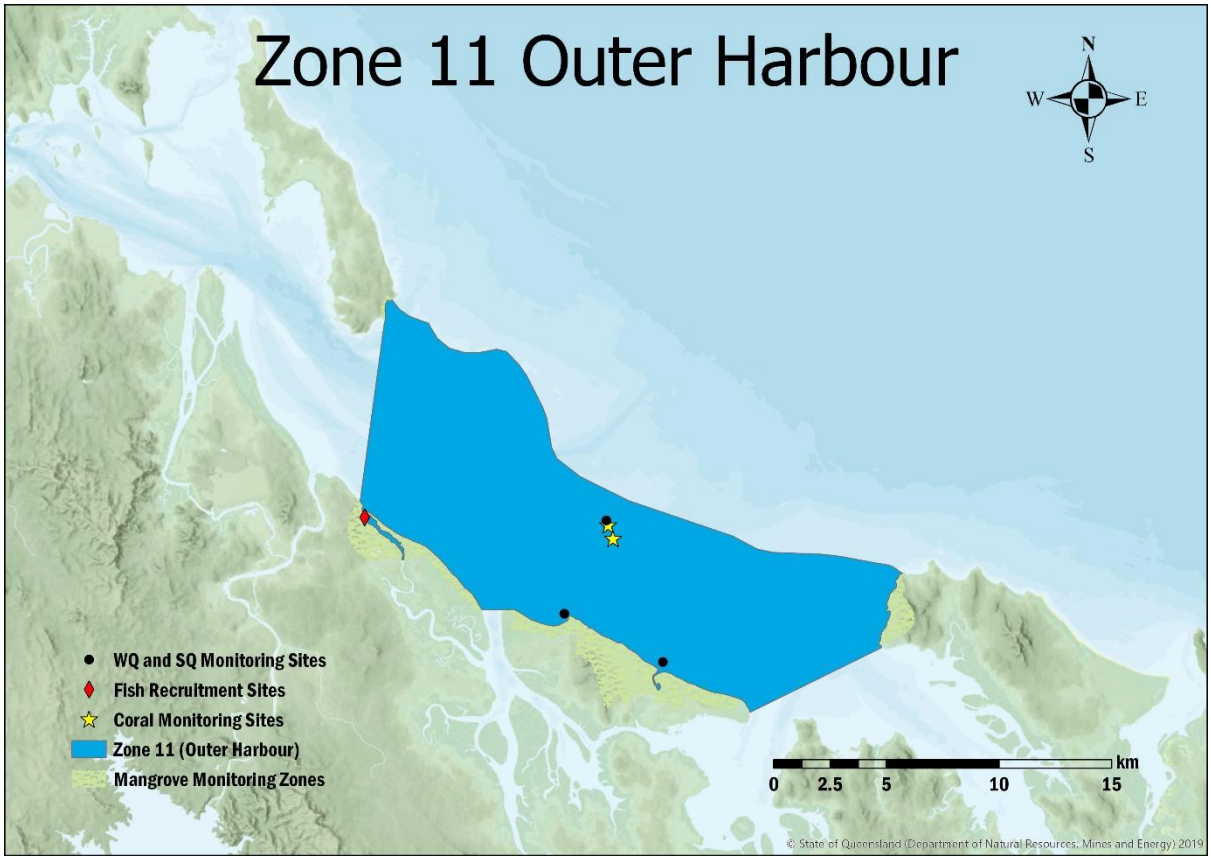

Figure 11.22 | Habitat types and sampling sites in the Outer Harbour.

MONITORING SITES

Water and Sediment Quality	3
Seagrass	0
Fish Recruitment	1
Mud Crab	0
Fish Health	Yes
Coral	2

Situated in open coastal waters between Facing Island and Rodds Bay, the Outer Harbour is the largest of the 13 monitoring zones. Just over 50% of this zone lies within the Gladstone Port Limits. The south-western boundary consists of long sandy beaches and salt pans and mangroves around the entrance to Colosseum Inlet. There are no major industries located along the coastlines of this zone. Coral reefs occur within the zone and there are two coral monitoring sites. The north-eastern boundary consists of open coastal water and a dredge material relocation area is located to the east of this boundary.

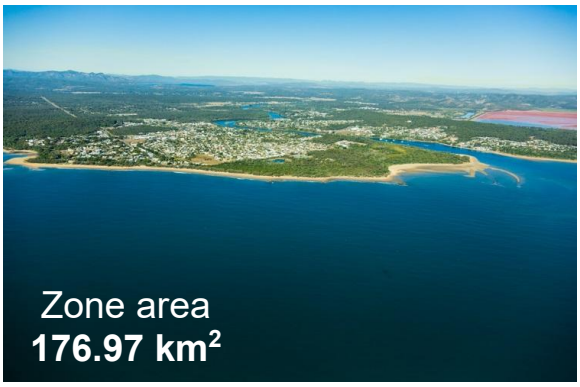

Figure 11.23 | The Outer Harbour and Tannum Sands photographed from the north-east. Boyne Island and one of Gladstone's red mud (bauxite) dams are on the right.

11.1.12 Colosseum Inlet

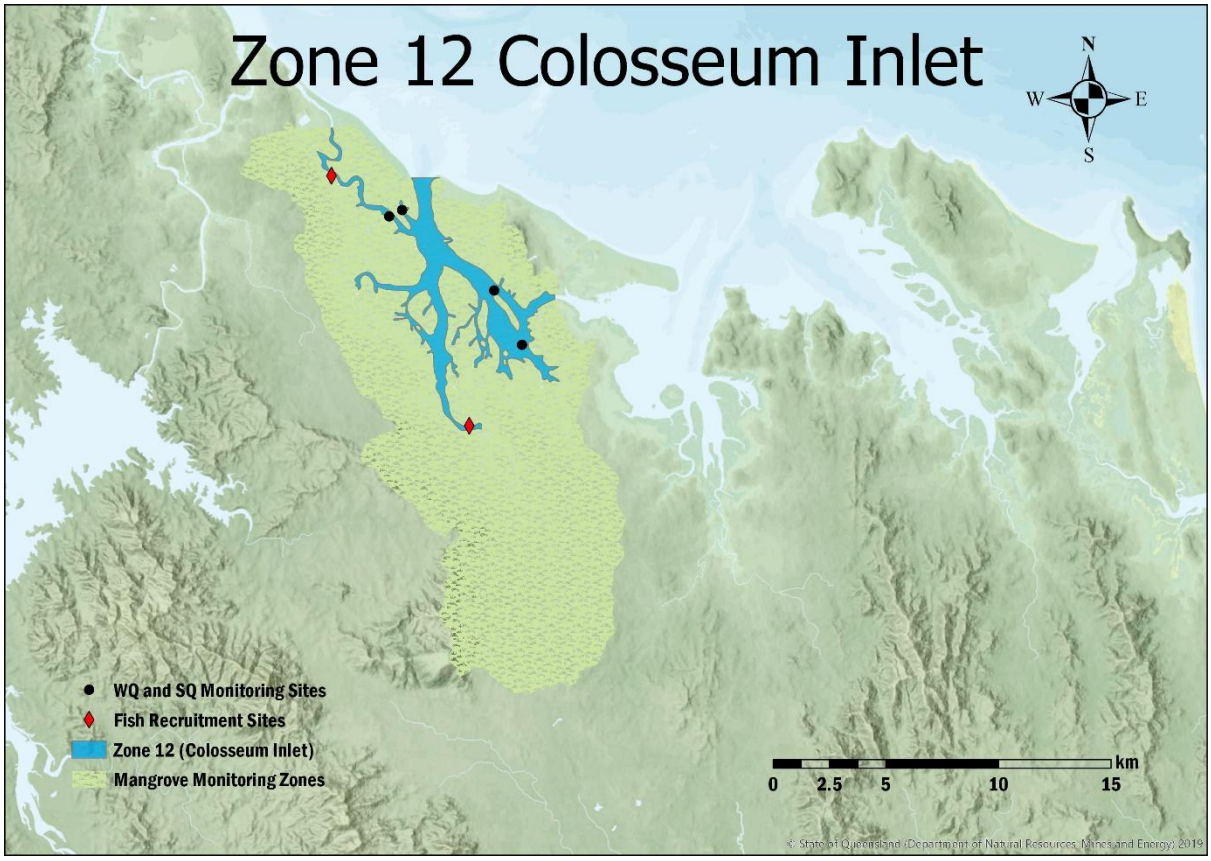

Figure 11.24 | Habitat types and sampling sites in Colosseum Inlet.

MONITORING SITES

Water and Sediment Quality	4
Seagrass	0
Fish Recruitment	2
Mud Crab	0
Fish Health	Yes

Colosseum Inlet is an estuarine zone that is sheltered by Hummock Hill Island. Colosseum Inlet connects to the Outer Harbour and Rodds Bay zones. The inlet has several large tributaries branching off the main creek and all are lined with mangroves and salt pan areas. There are no urban or industrial areas along the coastline of this zone.



Figure 11.25 | The northern entrance to Colosseum Inlet showing Wild Cattle Island on the right and Hummock Hill Island on the left.

11.1.13 Rodds Bay

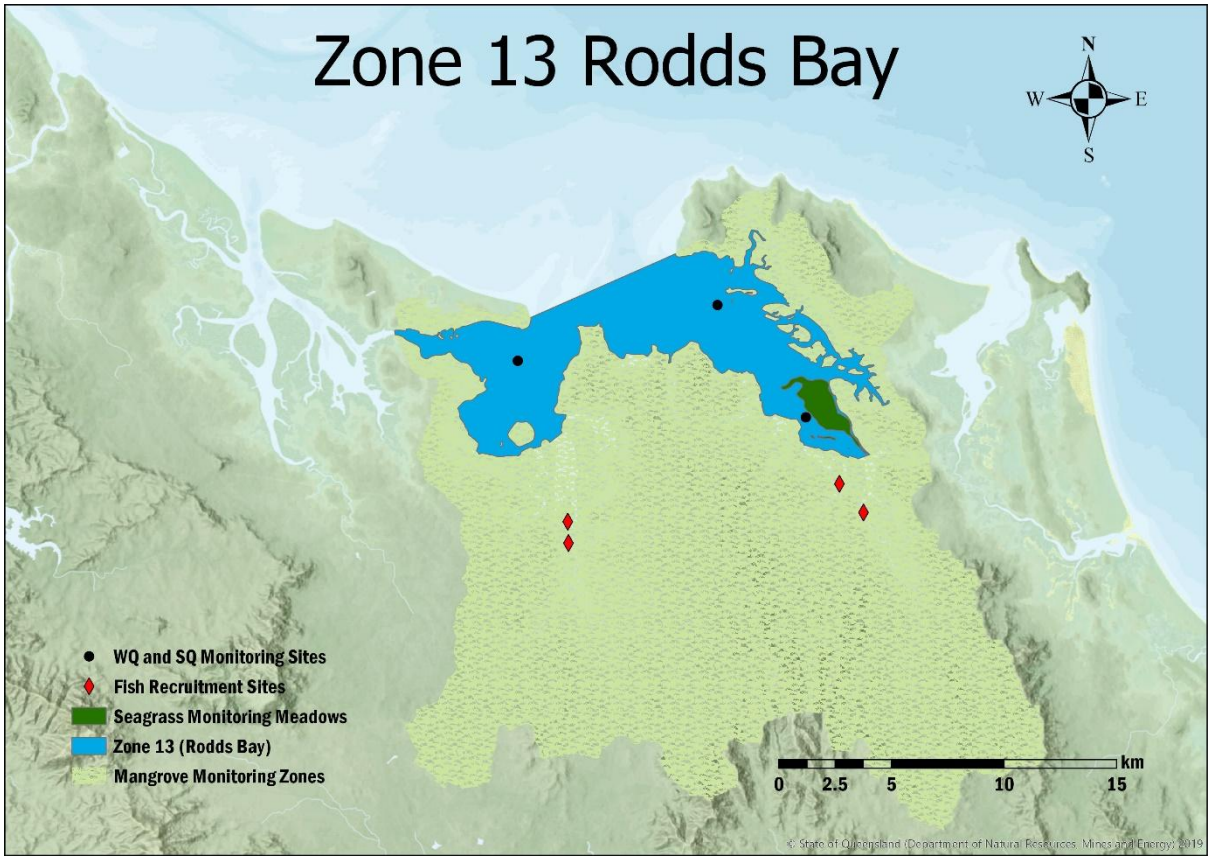

Figure 11.26 | Habitat types and sampling sites in Rodds Bay.

MONITORING SITES

Water and Sediment Quality	2
Seagrass	3
Fish Recruitment	4
Mud Crab	1
Fish Health	Yes

Rodds Bay is located to the south-east of the Outer Harbour zone. It is connected to Colosseum Inlet by a narrow channel behind Hummock Hill Island. The eastern side of Rodds Bay includes a number of mangrove islands. The creeks that flow into the bay are also mangrove-lined and contain large areas of salt pans. This zone also includes three monitored seagrass meadows and the Rodds Bay Dugong Protection area. This is a pristine zone that has biodiversity value (Vision Environment Queensland, 2011).

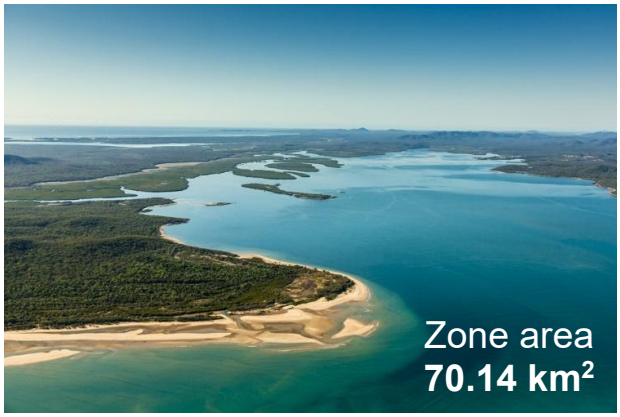

Figure 11.27 | The eastern arm of Rodds Bay showing Rodds Peninsula in the foreground.

11.2 Social, Cultural and Economic reporting areas

Data that contributed to the Social, Cultural (*Sense of Place*) and Economic scores were collected from the Gladstone Region. Participants in the CATI survey were selected from within the Gladstone 4680 postcode area (Figure 11.28). Hotel occupancy rates were based on the Gladstone Local Government Area. The GPC provided the shipping data for the Port of Gladstone.

Commercial fishing data were collected from the area within the Queensland Fisheries S30 Grid (QFish S30) and nearby open coastal waters of Mackay (Grid O25) and Rockhampton/Yeppoon (Grid R29). The latter two grids were used in the analysis to control for spatial differences in catch across years (Figure 11.29)

However, for the marine safety incidents and oil spills social indicator, data originated from Gladstone Maritime Region which includes 1868 km of mainland coastline from Double Island Point to St. Lawrence, 132 km of island coastline and 26,190 km of inland waterways. This region incorporates the Port of Gladstone, Port Alma, Port of Bundaberg and marinas in Hervey Bay, Bundaberg, and Rosslyn Bay (Windle et al., 2018).

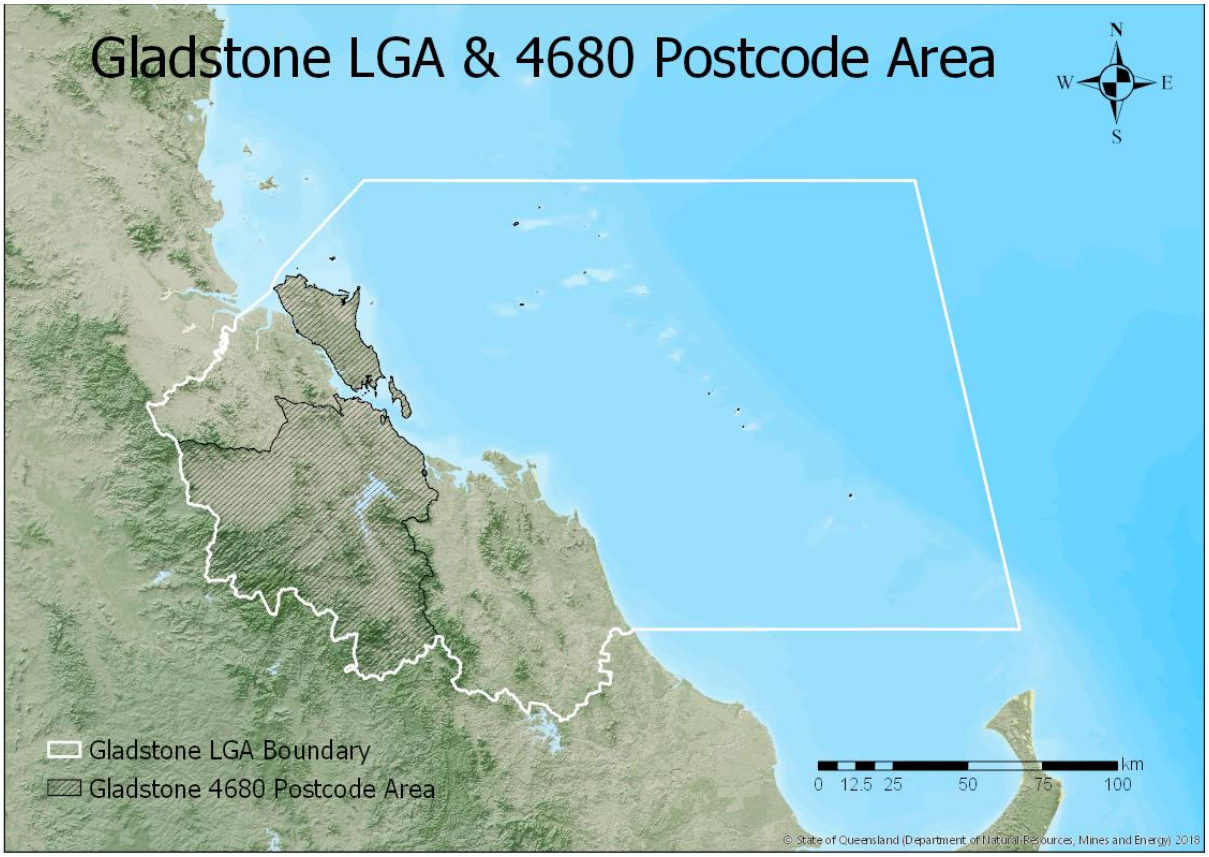

Figure 11.28 | The Gladstone Region showing the mainland extent of the Gladstone Local Government Area and the Gladstone 4680 postcode area. Both were used to define areas from which some social, cultural, and economic data were collected.

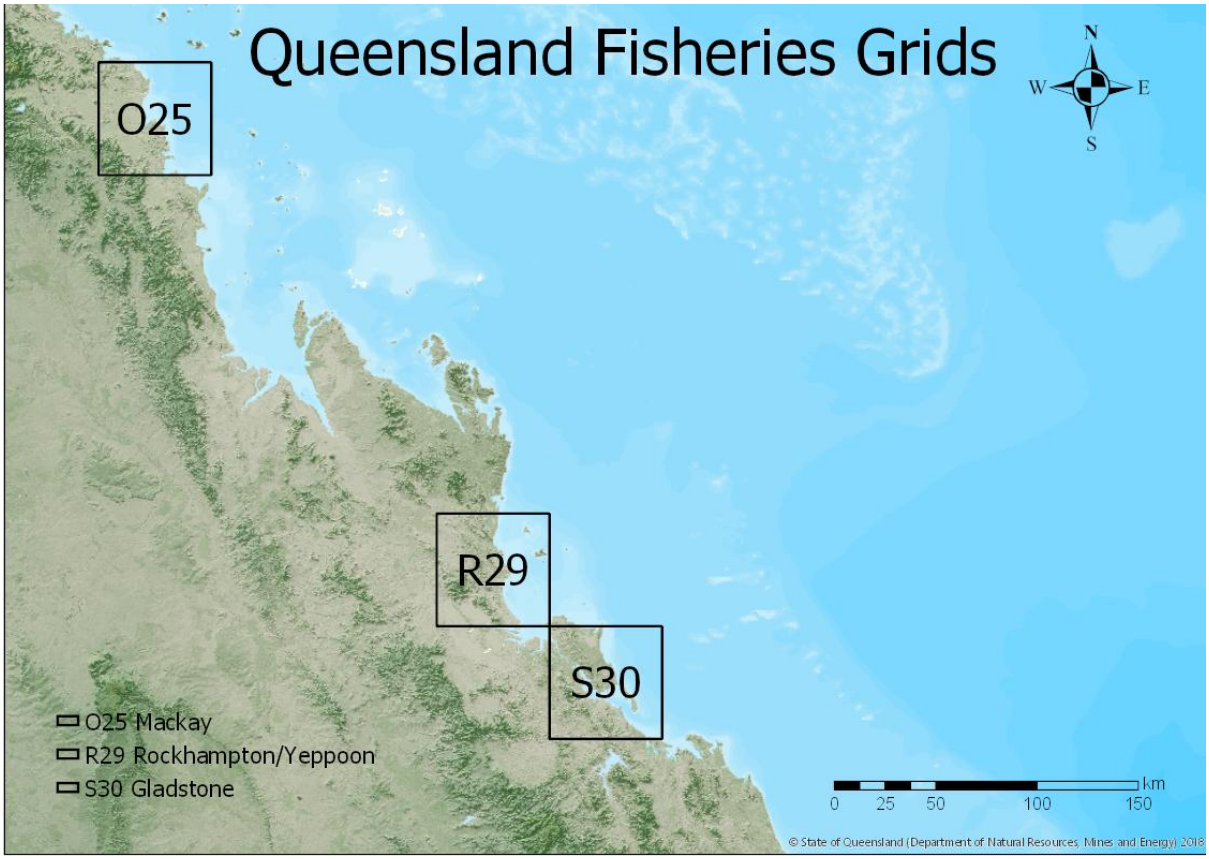

Figure 11.29 | The Queensland Fisheries S30 (Gladstone), R29 (Rockhampton and Yeppoon) and O25 (Mackay) Grids. Data from these grids are used to calculate the Commercial fishing indicator.

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13 Glossary

Terms and acronyms	Definition
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
Asset	A particular feature of value to the GHHP for monitoring and reporting, e.g. seagrass meadows or swimmable beaches
Baseline	A point of reference from which to measure change
CATI	Computer-assisted telephone interviewing
Component	The Gladstone Harbour Report Card will report on four components of harbour health: Environmental, Cultural, Social and Economic.
CPUE	Catch per unit effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DIMS	Data Information Management System
Ecosystem health	An ecosystem that is stable and sustainable, maintaining its organisation and autonomy over time and its resilience to stress. Ecosystem health can be assessed using measures of resilience, vigour and organisation. Source: http://www.biodiversity.govt.nz/picture/doing/nzbs/glossary.html
Environmental indicators	Metrics derived from observation used to identify indirect drivers of environmental problems (e.g. population growth), direct pressures on the environment (e.g. overfishing), environmental condition (e.g. contaminant concentrations), broader impacts of environmental condition (e.g. health outcomes) or effectiveness of policy responses (de Sherbinin et al., 2013)
GHHP	Gladstone Healthy Harbour Partnership
Guidelines and criteria	Science-based numerical concentration limits or descriptive statements recommended to support a designated water use. Guidelines are not legally enforceable.
Fish HAI	Health Assessment Index A thorough assessment of the health of individual fish based on visual condition and the condition of several internal organs and tissues.
Indicator	Numerical values that provide insight into the state of the environment, or human health etc. The environment is highly complex and indicators provide a simple, practical way to track changes in the state of the environment over time.
Liveability	In this report, liveability is used to refer to a *Sense of Place*, quality of housing, provision of health services, recreation facilities, attraction of the urban environment and availability of services.
Metadata	'data about data', the series of descriptors used to identify a particular dataset (e.g. author, date of creation, format of the data, location of the data points)

MMP	Marine Monitoring Program
Model/modelling	The creation of conceptual, graphical or mathematical models to describe, visualise or test abstract concepts and processes. Models help explain complex real-world interactions and add to our ability to understand how human actions impact on ecosystems. Models can be used to analyse scenarios to support decision making.
PCIMP	Port Curtis Integrated Monitoring Program
Physicochemical	Physical and chemical forces that influence the environment and the biodiversity and people within e.g. temperature, salinity
Point source	A single, identifiable localised source of a release e.g. a stormwater outlet
QA/QC	Quality assurance/quality control – the processes used to ensure the quality of a product (QA), and then to assess whether the product or services meet quality standards then correct where necessary to meet those standards (QC). Raw data may contain errors or be in formats unsuitable for further analysis, so appropriate QC needs to be applied to assess and correct data.
QFish	Queensland Fishing
Raw data (also 'primary data')	Data that have not been processed or otherwise manipulated apart from QA/QC to ensure accuracy
Reference condition	Recorded indicator values are compared against values from sites not impacted by human disturbance or alteration, or, which represent a control site considered to be 'healthy' (Connolly et al., 2013)
Standards	Legal limits permitted for a specific water body
TC	Tropical cyclone
TCM	Travel cost method
TropWATER	Centre for Tropical Water & Aquatic Ecosystem Research (James Cook University)
Visual fish condition	An automated visual assessment of images captured by fishers using a mobile phone app.
WICET	Wiggins Island Coal Export Terminal

Appendix 1. GHHP science projects

All project reports can be found on the GHHP website: www.ghhp.org.au/project-reports.

Project name and institution	Reports and publications
ISP001 Mapping and synthesis of data and monitoring in Gladstone Harbour AIMS	Llewellyn L, Wakeford M and McIntosh E (2013). *Mapping and synthesis of data and monitoring in Gladstone Harbour*. A report to the Independent Science Panel of the Gladstone Healthy Harbour Partnership, August 2013. AIMS, Townsville.
ISP002 Review of the use of report cards for monitoring ecosystem and waterway health	Connolly RM, Bunn S, Campbell M, Escher B, Hunter J, Maxwell P, Page T, Richmond S, Rissik D, Roiko A, Smart J, and Teasdale P (2013). *Review of the use of report cards for monitoring ecosystem and waterway health*. Report to: Gladstone Healthy Harbour Partnership, November 2013. Queensland, Australia.
ISP003 Models and indicators of key ecological assets in Gladstone Harbour CSIRO Wealth from Oceans Flagship	Dambacher JM, Hodge KB, Babcock RC, Fulton EA, Apte SC, Plagányi ÉE, Warne M and Marshall NA (2013). *Models and indicators of key ecological assets in Gladstone Harbour*. A report prepared for the Gladstone Healthy Harbour Partnership. CSIRO Wealth from Oceans Flagship, Hobart.
ISP004 Guidance for the selection of social, cultural and economic indicators for the development of the Gladstone Healthy Harbour Report Card CQUniversity	Greer L and Kabir Z (2013). *Guidance for the selection of social, cultural and economic indicators for the development of the Gladstone Harbour Report Card*. Report to the Gladstone Healthy Harbour Partnership, School of Human Health and Social Science. CQUniversity Australia, Rockhampton.

ISP005 Social, cultural and economic components CSIRO (2014 – 2015) CQUniversity (2016 – 2022)	Pascoe S, Cannard T, Marshall N, Windle J, Flint N, Kabir Z and Tobin R (2014). *Piloting of social, cultural and economic indicators for the Gladstone Healthy Harbour Partnership Report Card*. Draft report prepared for the GHHP by CSIRO, Oceans and Atmosphere Flagship. Cannard T, Windle J and Tobin R (2015). *Final Report on the Status of Economic, Social and Selected Cultural Indicators for the Gladstone Harbour 2015 Report Card.* Report for the Gladstone Healthy Harbour Partnership. CSIRO Oceans and Atmosphere Flagship. Australia. Windle J, De Valck J, Flint N and Star M (2016). Final report on the status of the social, cultural (*Sense of Place*) and economic components for the Gladstone Harbour 2016 Report Card. CQUniversity, Rockhampton. Windle J, De Valck J, Flint N and Star M (2017). Final report on the status of the social, cultural (*Sense of Place*) and economic components for the Gladstone Harbour 2016 Report Card. CQUniversity, Rockhampton. Windle J, De Valck J, Flint N and Star M (2018) Report on the status of the social, cultural (*Sense of Place*) and economic components for the Gladstone Harbour 2018 Report Card. CQUniversity, Rockhampton. De Valck J, Star M and Flint N (2019) Report on the status of the social, cultural (*Sense of Place*) and economic components for the Gladstone Harbour 2019 Report Card. CQUniversity, Rockhampton. De Valck J (2022) Final report on the status of the Social, Cultural (*Sense of Place*) and Economic components for the 2022 Gladstone Harbour Report Card. CQUniversity. Report to the Gladstone Healthy Harbour Partnership, July 2022.
ISP006 Development of a Gladstone Harbour Model to support the Gladstone Healthy Harbour Report Card CSIRO Wealth from Oceans Flagship	Fulton EA and van Putten I (2014) *Project ISP006: Milestone report December 2014*. CSIRO, Australia. Baird M and Margvelashvili N (2015) *Receiving Water Quality & Sediment Scenarios:* Final Report. CSIRO, Australia. Fulton EA, Hutton T, van Putten IE, Lozano-Montes H and Gorton R (2017) *Gladstone Atlantis Model – Implementation and initial results*. Report to the Gladstone Healthy Harbour Partnership. CSIRO, Australia.

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ISP011 Seagrass indicators Centre for Tropical Water & Aquatic Ecosystem Research (James Cook University)	Smith T, Carter AB and Rasheed MA (2022) *Gladstone Healthy Harbour Partnership 2022 Report Card Summary, ISP011: Seagrass*. Centre for Tropical Water & Aquatic Ecosystem Research James Cook University, Cairns. Smith T, Reason C and Rasheed MA (2023) *Gladstone Healthy Harbour Partnership 2023 Report Card Summary, ISP011: Seagrass*. Centre for Tropical Water & Aquatic Ecosystem Research James Cook University, Cairns. Smith T, Reason C and Rasheed MA (2024) *Gladstone Healthy Harbour Partnership 2024 Report Card Summary, ISP011: Seagrass*. Centre for Tropical Water & Aquatic Ecosystem Research James Cook University, Cairns. Smith T, Reason C and Rasheed MA (2025) *Gladstone Healthy Harbour Partnership 2025 Report Card Summary, ISP011: Seagrass*. Centre for Tropical Water & Aquatic Ecosystem Research James Cook University, Cairns. Smith T, Reason C and Rasheed MA (2026) *Gladstone Healthy Harbour Partnership 2026 Report Card Summary, ISP011: Seagrass*. Centre for Tropical Water & Aquatic Ecosystem Research James Cook University, Cairns.
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ISP013 Fish recruitment indicators Infofish Australia Pty Ltd and Dr Bill Venables	Sawynok B and Sawynok S (2024) *Fish recruitment indicators for the Gladstone Harbour Report Card using data derived from castnet sampling 2024.* Report for the Gladstone Healthy Harbour Partnership. Infofish Australia, Murarrie. Sawynok B and Sawynok S (2025) *Fish recruitment indicators for the Gladstone Harbour Report Card using data derived from castnet sampling 2025.* Report for the Gladstone Healthy Harbour Partnership, Gladstone. Infofish Australia, Murarrie. Sawynok B and Sawynok S (2026) *Fish recruitment indicators for the Gladstone Harbour Report Card using data derived from castnet sampling 2026.* Report for the Gladstone Healthy Harbour Partnership, Gladstone. Infofish Australia, Murarrie.
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	Thompson C, Thompson A and Davidson J (2024) *Coral Indicators for the 2024 Gladstone Harbour Report Card: ISP014.* Report prepared for Gladstone Healthy Harbour Partnership. AIMS, Townsville.
ISP014 Coral indicators AIMS	Thompson C, Thompson A and Davidson J (2025) *Coral Indicators for the 2025 Gladstone Harbour Report Card: ISP014.* Report prepared for Gladstone Healthy Harbour Partnership. AIMS, Townsville. Thompson C, Thompson A and Davidson J (2026) *Coral Indicators for the 2026 Gladstone Harbour Report Card: ISP014.* Report prepared for Gladstone Healthy Harbour Partnership. AIMS, Townsville.
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Appendix 2. Water Quality Objectives and guidelines used to calculate water quality scores

Zone	Level of Protection	Physicochemical				Nutrients			Metals					
		Turbidity		*pH range*										
		Dry (NTU)	Wet (NTU)	<40 ms/cm	>40 ms/cm	TN (µg/L)	TP (µg/L)	Chl-*a* (µg/L)	Al (µg/L)	Cu (µg/L)	Pb (µg/L)	Mn (µg/L)	Ni (µg/L)	Zn (µg/L)
1. The Narrows	HEV	7	15	7.2–8.2	7.4–8.3	170	20	1	24	1.3	4.4	80	7	15
2. Graham Creek	MD	8	13	7.2–8.2	7.4–8.3	170	20	1	24	1.3	4.4	80	7	15
3. Western Basin	MD	8	13	7.2–8.2	7.4–8.3	170	18	1	24	1.3	4.4	80	7	15
4. Boat Creek	MD	14	25	7.2–8.2	7.4–8.3	190	22	2	24	1.3	4.4	80	7	15
5. Inner Harbour	MD	8	13	7.2–8.2	7.4–8.3	160	21	1	24	1.3	4.4	80	7	15
6.Calliope Estuary	MD	11	11	7.2–8.2	7.4–8.3	175	22	1.7	24	1.3	4.4	80	7	15
7.Auckland Inlet	MD	6	8	7.2–8.2	7.4–8.3	160	16	1.9	24	1.3	4.4	80	7	15
8.Mid Harbour	MD	4	9	7.2–8.2	7.4–8.3	135	14	1	24	1.3	4.4	80	7	15
9. South Trees Inlet	MD	11	13	7.2–8.2	7.4–8.3	170	20	1.1	24	1.3	4.4	80	7	15
10. Boyne Estuary	MD	3	5	7.2–8.2	7.4–8.3	120	11	0.8	24	1.3	4.4	80	7	15
11. Outer Harbour	MD	3	7	8.0–8.2		130	13	1	24	1.3	4.4	80	7	15
12. Colosseum Inlet	HEV	3	7	7.2–8.2	7.4–8.3	130	10	0.8	24	1.3	4.4	80	7	15
13. Rodds Bay	HEV	4	5	7.2–8.2	7.4–8.3	160	13	1	24	1.3	4.4	80	7	15

Note: Water Quality Objectives and guideline values provided by DEHP Water Quality Objectives for the Capricorn Curtis Coast (DEHP, 2014) for pH, turbidity and nutrients; ANZG (2018) for metals in water and sediments (except aluminium); and Golding et al. (2014) for aluminium in marine waters.

Turbidity: The 50th percentile from the guideline values is applied to all harbour zones. Dry season guidelines apply from May to October. Wet season guidelines apply from November to April. NTU: nephelometric turbidity unit.

pH range: The pH range falls between the 20th and 80th percentile of the guideline values. Different guideline values are applied for conductivity measurements of <40 ms/cm and >40 ms/cm.

Nutrients: For all nutrients, total nitrogen (TN), total phosphorus (TP) and chlorophyll-*a* (Chl-*a*) the 50th percentile from the guideline values is applied.

Aluminium: The aluminium (Al) guideline for moderately disturbed (MD) systems (24 µg/L, 95% species protection) is applied to all harbour zones.

Manganese: The manganese (Mn) guideline (80 µg/L) from the ANZG (2018) water quality guidelines is applied to all harbour zones.

Other Metals: The 95% species protection value from the ANZG (2018) water quality guidelines is applied to copper (Cu), lead (Pb), and zinc (Zn) while the 99% species protection value is applied to nickel (Ni). Trigger values were selected for moderately disturbed systems.

Appendix 3. Sediment quality guidelines used to calculate sediment quality scores

Indicator	Measure	Concentration (mg/kg)	Guideline based on
Metals and metalloid	Arsenic (As)	20	ANZG, 2018
	Cadmium (Cd)	1.5	ANZG, 2018
	Copper (Cu)	65	ANZG, 2018
	Lead (Pb)	50	ANZG, 2018
	Mercury (Hg)	0.15	ANZG, 2018
	Nickel (Ni)	21	ANZG, 2018
	Zinc (Zn)	200	ANZG, 2018

Appendix 4. Data filtering methods for Natural Resource Management (NRM) area litter metric report card

By: Jordan Gacutan (UNSW, Sydney)
Prepared for: Fitzroy Basin Association (FBA) [host of Gladstone Healthy Harbour Partnership in 2021–22]
On behalf of: Tangaroa Blue Foundation and UNSW, Sydney

Summary
The following brief provides an overview of the methods used to process the Australian Marine Debris Initiative (AMDI) database (henceforth **'raw data'**) to a '**custom dataset'**, as in input for the model described in Whitehead and Venables (2019).

Rationale

- Support continued monitoring of litter to detect changes due to source reduction / policy implementation within Great Barrier Reef catchments.
- Standardise litter reporting across NRMs, supported by the AMDI database.
- Implementation of Australian Marine Debris Initiative in reporting and decision-making.
- Support the UN Sustainable Development Goals [14.1.1, marine plastic pollution].

Figures
Figure A4.1 | Data pipeline for project, to extract key items# (plastic bags, plastic bottles, single-use cutlery, and cigarettes) from the Australian Marine Debris Initiative (AMDI) database for annual use in a statistical model, for production of litter scores and grades. NRM = Natural Resource Management area, NB = Negative binomial.

Tables
Table A4.1 | Data quality filters used to process the Australian Marine Debris Initiative database. Filters are in sequential order.
Table A4.2 | Provided shapefiles used to classify data by NRM reporting needs.

Description

This project extends the statistical model and analyses presented in the report "Litter Score and Grade Proposal for Townsville". The existing model has been implemented for the Natural Resource Management (NRM) area 'Dry Tropics' (DT). The model, and required data processing, have been extended to the 'Wet Tropics' (WT) and 'Mackay-Whitsunday-Isaac' (MWI) NRMs.

In December 2020, Tangaroa Blue Foundation (TBF) and UNSW, Sydney were asked to provide a data pipeline, to process raw data from the AMDI dataset for use in a statistical model. The pipeline facilitates the extraction and processing of data for future reporting needs. Tasks to be performed by UNSW, Sydney are described in the '**data sharing agreement**' between Tangaroa Blue Foundation, UNSW, Sydney, and the report card body.

The data pipeline involves filtering (1) data quality, (2) spatially to the reporting area, and (3) model use, described in Figure A4.1. Treatment of **ReefClean** data is described in Section 1.

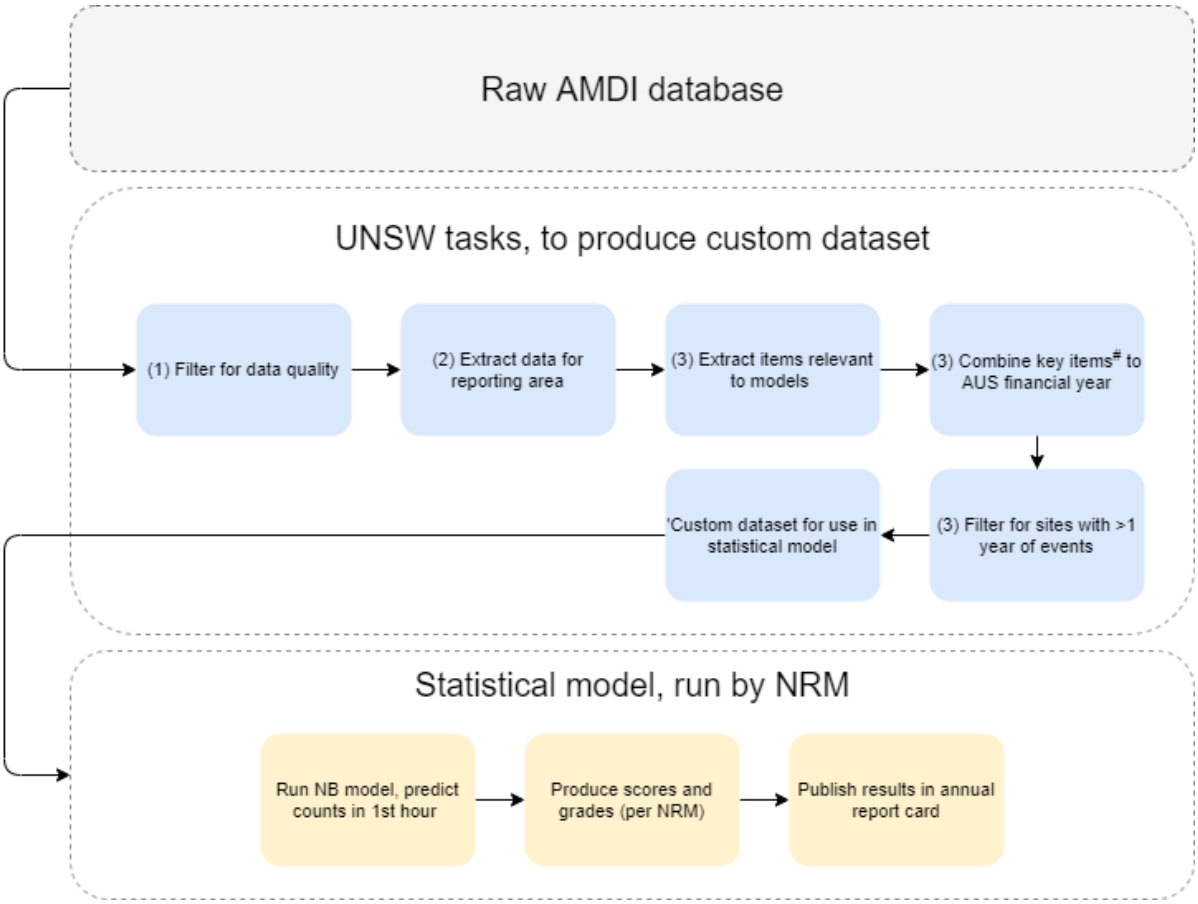

Figure A4.1 | Data pipeline for project, to extract key items# (plastic bags, plastic bottles, single-use cutlery, and cigarettes) from the Australian Marine Debris Initiative (AMDI) database for annual use in a statistical model, for production of litter scores and grades. NRM = Natural Resource Management area, NB = Negative binomial.

Filter for data quality

Filtering for data quality is taken from methods and related scripts of the publication, 'Continental trends in marine debris revealed by a decade of citizen science' (*in prep*). The filters used are presented in Table A4.1. As the work in is in preparation, scripts are currently unavailable.

ReefClean data was identified and processed separately, aggregating all transects and debris collected in surrounding areas, to align with data from community clean-ups stored within the AMDI database. Loss of resolution was justified by model needs.

Table A4. 1 | Data quality filters used to process the Australian Marine Debris Initiative database. Filters are in sequential order.

Cleaning theme	Tool used	Cleaning step	Examples / Description
Original database	DB Browser for SQL lite	Original database (Downloaded January 2021)	N/A
Limit to Australia	ArcMap 10.6	Remove foreign entries	Hawaii / Tonga / NZ / PNG / Timor Leste
	ArcMap 10.6 / Nearmap	Remove Australian external territories	Christmas island / Norfolk Island / Cocos Islands
Limit timeframe	DB Browser for SQL lite	Filter for Jan 2009 - Dec 2018	-
Clean by event entries	DB Browser for SQLite / R	Remove duplicate sites	-
		Clean-up time < 0.25 hours	Non-exhaustive clean-up.
		One volunteer, < 1 kg	A single volunteer collecting less than 1 kg indicates a non-exhaustive or informal clean-up
Clean by event entries	R / Excel	One volunteer, > 10 hours	Single volunteer cleaning more than 10 hours (indicates multiple days / weeks / months collecting)
		Not a clean-up	Daily walk / hike / Anecdotal as described in notes
		Estimated / incomplete	Stated in event notes
		Anecdotal (stated in notes)	Stated in event notes
		Clean-up over multiple days / weeks / month	Stated in notes, hours reported > 24
		Data quality poor	Number of volunteers / time / date or other details missing.
		Single item reported	Stated in event notes
		Timor Leste	Incorrectly entered as Australian site w/ incorrect coordinates
		Remove fishing line bin entries	Fishing bin Initiative hosted in the AMDI database
Event clean (Ratios of variables used to clean database)	R	bags / volunteer > 8	Volunteers collected more than 8 bags each (accuracy of data)
		Weight / volunteer > 10 & wt /bag > 10	Volunteers collected more than 10 bags weighing 10 kg each (accuracy of data)
		Hours per volunteer > 10 (i.e. each volunteer worked + 10 hrs)	Indicates poor data quality or multiple clean-ups over a longer timeframe
Clean events by item entries	R	Single item	Single item reported at the event (not in notes)
		Components < 10	Less than 5 item categories reported
		Estimated (div 10, integers)	Entries with integers divisible by 10 (estimated item categories > 50%)

Extract data for reporting areas

Processed data was classified according to NRM reporting areas and 'Water Type', as defined in Environmental Protection (Water) Policy 2009 (Qld, s. 12). Reporting areas and water types were classified by provided spatial data. Provided data and **custom dataset** were manipulated in ArcMap 10.7.

Table A4.2 | Provided shapefiles used to classify data by NRM reporting needs.

Shapefile name	Providing organisation
FPRH_Catchments	Fitzroy Partnership for River Health (FPRH)
2013_14 WQ Zones All Zones	Gladstone Healthy Harbour Partnership (GHHP)

Manipulate extracted data for use in model

To align with model structure, the following steps were performed:

a) Policy relevant items (plastic bags, plastic pottles, single-use items) were extracted.
b) Events were classified to financial year. Multiple events per site, per year were classified as 'Replicates'.
c) To avoid model collapse, sites with less than **one financial year** were filtered from analysis.

The resulting data was then provided to each NRM.

Appendix 5. Gladstone litter clean-up site data 2014–18

Table A5.1: Scores and grades for Gladstone litter clean-up sites from 2014–2018 (financial years (FYs)) sourced from the Australian Marine Debris Initiative (AMDI) Database.

Zone	Site	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019
The Narrows	Phillipies Landing Rd, Targinnie	NA	NA	NA	55 (MP)	NA
Mid Harbour	Canoe Point, Tannum Sands	NA	86 (VLP)	87 (VLP)	79 (LP)	86 (VLP)
	Esplanade Beach, Curtis Island	NA	NA	NA	NA	26 (HP)
	Facing Island North Point	NA	NA	NA	37 (HP)	NA
	North West Shore, Facing Island	NA	NA	NA	52 (MP)	NA
	Tannum Sands Main Beach	NA	NA	93 (VLP)	86 (VLP)	85 (VLP)
Western Basin	Fisherman's Landing, Gladstone	NA	96 (VLP)	NA	89 (VLP)	93 (VLP)
Calliope Estuary	Barney Point, Gladstone	NA	NA	82 (VLP)	81 (VLP)	35 (HP)
South Trees Inlet	Lillys Beach North End, Tannum Sands	NA	NA	NA	66 (LP)	48 (MP)
Boyne Estuary	Bray Park to Boyne River mouth	76 (LP)	80 (VLP)	NA	100 (NA)	65 (LP)
	Lilleys Beach	NA	86 (VLP)	88 (VLP)	81 (VLP)	62 (LP)
Outer Harbour	Wild Cattle Creek Boat Ramp, Tannum Sands	NA	NA	NA	74 (LP)	41 (MP)
	Wild Cattle Creek Mouth, Tannum Sands	91 (VLP)	85 (VLP)	65 (LP)	56 (MP)	53 (MP)
Rodds Bay	The Esplanade Beach, Turkey Beach	NA	NA	NA	81 (VLP)	68 (LP)
Calliope	Auckland Creek, Gladstone	NA	NA	NA	90 (VLP)	59 (MP)
	Auckland Creek, Golf Course Rd	NA	NA	NA	89 (VLP)	87 (VLP)
	Auckland Creek, Hanson Road, Gladstone	NA	NA	NA	NA	48 (MP)
	Auckland Creek, Lions Park	NA	NA	NA	NA	69 (LP)
	Boat Creek Gladstone	NA	NA	NA	95 (VLP)	NA
	Briffney Creek, Gladstone	NA	NA	98 (VLP)	44 (MP)	58 (MP)
	Calliope River Campgrounds Old Bruce Hwy	NA	NA	NA	55 (MP)	32 (HP)
	Calliope River, Gladstone Power Station	NA	NA	NA	NA	78 (LP)
	Hazelbrook Park, Calliope	NA	NA	NA	NA	91 (VLP)
	Lake Callemondah	NA	91 (VLP)	95 (VLP)	54 (MP)	51 (MP)
	Tigalee Creek, Sun Valley Park, Gladstone	NA	NA	97 (VLP)	91 (VLP)	78 (LP)